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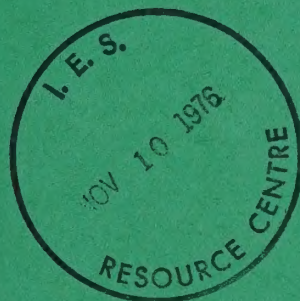
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# Review of Environmental Control of Mercury in Japan



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Economic and Technical Review  
Report EPS 3-WP-76-7

Water Pollution Control Directorate  
August, 1976



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REVIEW OF ENVIRONMENTAL CONTROL OF  
MERCURY IN JAPAN

by

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ENVIRONMENT CANADA

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# ABSTRACT

Papers presented at the International Congress of Scientists on the Human Environment, Kyoto, Japan, 1975, relating to observations of Japanese scientists on the Canadian mercury pollution situation, have been summarized and are discussed.

Japanese legislation relating to mercury discharges is reviewed, as well as compensation law, clean-up procedures, and financial assistance provided to chlor-alkali plants converting from mercury to diaphragm cells.

Several industrial installations were visited, and the mercury control measures and technology at two Japanese chlor-alkali plants are discussed in some detail.

RESUME

L'auteur résume et commente les communications présentées à Kyoto au Japon en 1975 au Congrès international des chercheurs dans le domaine de l'environnement humain et qui traitent des observations des chercheurs japonais sur l'état de la pollution par le mercure au Canada.

Il passe en revue des lois japonaises qui ont trait aux rejets de mercure de même que la loi sur les indemnisations, les modes de dépollution et les subventions accordées aux fabriques de chlore afin qu'elles abandonnent l'emploi des électrolyseurs à mercure au profit des électrolyseurs à diaphragme.

Plusieurs usines ont été visitées, et l'auteur examine de façon détaillée les méthodes et les techniques adoptées par deux fabriques de chlore japonaises pour empêcher la pollution par le mercure.



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## 1. INTRODUCTION

In the summer of 1975 a group of Japanese scientists visited Canada to investigate alleged cases of mercury poisoning among the Indians of the White Dog and Grassy Narrows reserves in the Kenora, Ontario area.

They made medical, social and technical observations and anticipated the publication of their findings at the International Congress of Scientists on the Human Environment to be held in Kyoto, Japan on November 17 to 26, 1975. During their visit here, the group was very critical of industry and government handling of the situation, and their views were widely quoted in the Canadian press. The Canadian public was, as a result, presented with a great deal of inaccurate and misleading information.

It was decided, therefore, to have a representative from Environment Canada attend the International Congress, to report any significant information and to attempt to correct any misrepresentation of the Canadian situation. Therefore, Dr. L. Buffa, who was coordinating the Department's effort on mercury at the time, attended the Congress.

While in Japan, he visited the Environmental Agency, the Ministry of Industry, Trade and Commerce, the Japanese Soda Association and a few selected industrial installations, in order to gain an understanding of the country's environmental approach to the control of mercury pollution.

This report comprises information received from government and industry personnel and at various meetings. It provides an overall up-to-date view of the actions taken to control mercury pollution in Japan. The amount of information obtained was somewhat limited by time constraints and a general strike affecting transportation within the country.

The author wishes to warmly acknowledge the cooperation and help received by the numerous agencies, associations and individuals met in the course of his visit to Japan.

Special thanks are due to Dr. R.M.J. Bower and Mr. T. Watanabe of the Canadian Embassy in Tokyo.

## 2. THE INTERNATIONAL CONGRESS OF SCIENTISTS ON THE HUMAN ENVIRONMENT

### 2.1 Background

The Congress, held November 17-26, 1975, in Kyoto, included a special session on mercury poisoning. Three papers were presented and a discussion was held dealing exclusively with mercury pollution in the Kenora, Ontario area and its handling by Canadian authorities. The three papers were presented by Japanese scientists who had visited the Kenora area. The discussion was led by Mr. J. Ui, who has spent a great deal of time studying the effects of mercury poisoning, and has collected data on mercury discharges in many parts of the world. He is well known for his outspoken views on the mercury situation in many countries outside of Japan.

Minamata Disease is a subject that attracts considerable press and television attention in Japan, and the Japanese media are apparently well known for their liberal interpretation of statements made at public meetings or by individuals during interviews. The session on Canadian problems was attended by at least two dozen reporters and TV cameramen.

### 2.2 Papers on Canadian Mercury Poisoning

C4401 - "Environment and Development; the Canadian Arctic Today", by Dr. M.R. Freeman, McMaster University, Hamilton, Ontario.

This presentation consisted of slides showing the Canadian Arctic, with mention of its fragile ecosystem. Concern was expressed over the accelerating mineral and oil exploration activity, and its effects on the native inhabitants.

C4402 - "Medical Diagnosis of Canadian Indians in the Mercury Polluted areas", by M. Harada, Kumamoto University, Japan.

The presentation was strictly limited to medical findings and consisted of slides drawing comparisons between the symptoms shown by Canadian Indians affected by mercury to those shown by Minamata patients. Mercury levels in hair of the Indians at Grassy Narrows were reported to be the same as those found at Minamata. This point is discussed further and partly contradicted in Section 4.4 of this report, which deals with mercury in hair.



No written paper was circulated. A general chronology and medical report on Minimata Disease by Dr. Harada is available for reference [1].

C4403 - "The Cause and Channels of Mercury Pollution in the Kenora Area", by J. Nakanishi, University of Tokyo, Japan (see Appendix I).

The paper was summarized by slides showing mercury levels in fish and sediments. This presentation attempted to draw the conclusion that only citizen action against the government could stop mercury pollution in the Kenora area. The control measures which have been taken by the Dryden Paper Co., and its planned conversion to a nonmercury cells process, were not mentioned. A figure of 9 to 10 tons of mercury per year was reported to be discharged by Dryden. The audience was left with the impression that the data presented, obtained from 1969 and 1970 surveys, were representative of present conditions.

C4404 - "Life of Canadian Indians and the Influence on it Caused By Mercury Poisoning", by N. Iijima University of Tokyo, Japan (see Appendix II).

This presentation, in slides, attempted to make a maximum emotional impact on the audience. Slides were shown of Indian homes lacking elementary sanitary facilities such as a water supply and indoor toilets.

The author claimed that the mercury pollution was the result of discrimination by a dominating class, and that government was not taking any steps to prevent the mercury discharges.

C4409 - Discussion, led by Mr. J. Ui, University of Tokyo, Japan.

Mr. Ui presented a table containing his observations of mercury discharges in different parts of the world and their effect on mercury levels in fish. They were as follows:

TABLE 1. MERCURY DISCHARGES AND HG LEVELS IN FISH.

|           | Hg discharges | Hg level in fish |
|-----------|---------------|------------------|
| Tokyo     | 100 kg/day    | 0.1 ppm          |
| Minamata  | 10 kg/day     | 10 ppm           |
| Stockholm | 2 kg/day      | 1 ppm            |
| Odda      | 0.5 kg/day    | 1 ppm            |
| Dryden    | 3 kg/day      | 10 ppm           |
| Ravenna   | 10 kg/day     | 1 ppm            |

No attempt was made to qualify the data, leaving the audience with the clear impression that governmental action has been inadequate in all cases.

After the discussion Mr. Kawamoto, a representative of the Minamata victims, delivered an appeal to all the scientists attending the congress to cooperate to convince and force governments to stop discharges of mercury into the environment.

### 2.3 Press Coverage

Given the media coverage of the presentations and the direction taken by the discussion on Canadian problems, an informal statement to correct the records was considered necessary by Dr. Buffa. His comments, made during the discussion, received ample coverage both on the national TV network (NHK) and in the newspapers.

A more formal and comprehensive review of the actions taken by the Canadian Government was presented in a special interview with the NHK TV network. Apparently, this interview was never shown.

Clips of the press coverage of the Canadian situation are shown in Appendix III.

Appendix IV contains a summary of the papers and discussions, as prepared by the Congress Secretariat.

### 2.4 Comments

From the tone of the presentations and the discussion, and from private conversations, it was clear that opinions on Minamata Disease, its causes and the remedial action, were completely polarized. Such a polarization appeared to be accepted as the normal occurrence by the Japanese; neither side was expected to be objective, especially at public meetings. This situation proved to be a continuous difficulty throughout most of the discussions at the Conference.

The presentations by the Japanese scientists who had visited Canada appeared to be designed to make a maximum emotional impact on the audience. Since the scientists are part of a pressure group which advocates more governmental action, they were expected to take advantage of this approach.



The author's comments during the discussion period somewhat balanced the effect of the presentations. However, without being able to read the Japanese newspapers, it was impossible to obtain a comprehensive view of the reactions of the media to the session on mercury poisoning in Canada.

The list of participants and abstracts of the papers that were presented at the congress are available in English for reference [2].

### 3. CURRENT REQUIREMENTS TO CONTROL MERCURY LOSSES TO THE ENVIRONMENT

#### 3.1 Water

There are two types of requirements for effluents control in Japan:

- regulations, or standards, issued by the Environmental Agency; and,
- guidelines, issued by the Ministry of the Interior, Trade and Industry (MITI).

The following standards apply to all industrial discharges of mercury. They are expressed as concentration of mercury in wastewaters:

|                                |          | Standard Value     | Reference Method                     |
|--------------------------------|----------|--------------------|--------------------------------------|
| Wastewater Discharge Standards | Total Hg | 50 ppb             | Flameless A.A.                       |
|                                | Alkyl Hg | Not detectable (*) | Gas chromatography<br>Flameless A.A. |

(\*) Not detectable means  $\leq 0.5$  ppb.

Standards have also been issued for water quality, as follows:

|                           |          |                    |                                      |
|---------------------------|----------|--------------------|--------------------------------------|
| Ambient Quality Standards | Total Hg | 0.5 ppb            | Flameless A.A.                       |
|                           | Alkyl Hg | Not detectable (*) | Gas chromatography<br>Flameless A.A. |

(\*) Not detectable means  $\leq 0.5$  ppb.

The following administrative guidelines have been issued (by MITI) to all chlor-alkali plants:

- 1) All process water contaminated with mercury must receive full recycle by December 1973.
- 2) Mercury cells must be phased out by March 1978.



Each plant is required, by law, to carry out monitoring of its own effluents, with spot checks being carried out by the local authority (Prefecture or Municipality). Spot checks are carried out on the effluents of all plants operating mercury cells and four PVC plants.

There appears to be a contradiction between the guideline requiring conversion and the high level of control already attained (and capital invested) by some plants. This could be explained by the fact that the Environment Agency and MITI are independent agencies. While chlor-alkali plants may have reached compliance with the Agency standards, they still have to comply with MITI's guidelines. Because of political considerations, there is a reluctance to review the guidelines even for plants already showing a high degree of control.

### 3.2 Solid Waste

Solid Waste Control Law states that\*:

- i) Sludges and muds with an Hg content  $\leq 0.005$  ppm may be used as landfill.
- ii) Sludges and muds with an Hg content  $> 0.005$  ppm must be mixed with concrete. When, after mixing, leaching tests show an Hg content  $> 0.005$  ppm in the leachate, the blocks must be imbedded in additional larger blocks.

### 3.3 Air

Requirements for mercury emissions to the atmosphere have not yet been put into final form. It is expected that future regulations will specify a maximum Hg concentration at exhaust fans of  $50 \mu\text{g}/\text{m}^3$ .

Air background in Japan contains Hg at a level of 0.05 to  $1.0 \mu\text{g}/\text{m}^3$ .

### 3.4 Ocean Contamination Law\*\*

- i) Sludges and muds with an Hg content  $\leq 0.005$  ppm may be disposed at sea where the depth is  $\geq 3,500$  m.
- ii) Sludges and muds with an Hg content  $> 0.005$  ppm must be mixed with concrete. The blocks may be dumped in areas

---

\* Information obtained through verbal communication.

\*\* Information obtained through verbal communication.

with low currents and scarce fish. This dumping is subject to the condition that leaching tests show Hg < 0.005 ppm.

iii) Sludges and muds with Hg content < 2.0 ppm may be dumped in deep areas with scarce fish.

iv) Any liquid or sludge or mud with an Hg content  $\geq$  2.0 ppm must be treated or incinerated. The quantity of sludges incinerated is, apparently, minor.

### 3.5 Compensation Law

Details on this law were obtained indirectly and the information reported below reflects only the author's understanding of the procedure.

In essence, this law was initially designed to provide compensation for health damage due to air or water pollution.

The first step is the designation of a geographical area affected by an environmental disease, i.e. "Kogai area". There follows a designation of the disease in the area, i.e. "Kogai disease", which has occurred because of pollutants from industrial activities in the area.

The designation of an area apparently follows the establishment that there is an epidemic of an environmental disease in the area. Individual patients are then verified as victims of the disease and these "designated patients" are ranked according to scale of severity.

Pressure groups have expressed considerable criticism of the amount of evidence needed by government officials to acknowledge that an epidemic exists. On the other hand, government officials stress the need for careful evaluation before designating an area as affected by an epidemic of an environmental disease.

There has also been controversy over several individual cases which environmental groups consider should be recognized as Minamata Disease cases, while the authorities are of different opinion. Cases of Minamata Disease have been reported in other areas close to chlor-alkali plants (Ariake Sea, Tokuyama [10]). The press has supported the claims of the environmental groups and has criticized the position of the authorities. The social stigma associated with Minamata Disease has also apparently prevented some victims from requesting to be checked and verified as patients.



The verified Minamata patients have been compensated as follows:

- 1) lump sums, \$60,000 for death or "A" ranked patients. (This sum was voluntarily paid by the Chisso Corporation factory in one instance and, therefore, was established as a precedent.); \$58,000 and \$56,000 for patients ranked "B" and "C", respectively;
- 2) medical expenses and nursing allowances;
- 3) pensions from \$180 to \$200 per month depending upon rank; and,
- 4) funeral expenses.

### 3.6 Removal of Mercury Contaminated Sediments

The Environment Agency has established a provisional standard of 25 mg/l for the removal of sediments contaminated with mercury. Its application is as follows\*:

- i) Fresh water: all sediments with mercury content  $\geq 25$  mg/l should be removed.
- ii) Sea water: an attempt has been made to take into consideration the cleansing effect of tides and the leaching properties of a given sediment.

Sediments should be removed when

$$C = K \times \frac{\Delta H}{j} \times \frac{1}{S} \geq 25 \text{ mg/l}$$

where:

K = constant, 0.18

$\Delta H$  = average tide range in the area, expressed in metres

j = solubility of the mercury contained in the sediments. It is determined by stirring 4 cc of sediment into 100 cc of sea water. j is the ratio of mercury dissolved into the 100 cc of water over the mercury remaining in the 4 cc of sediment. (More precise information on this test could not be obtained.)

s = safety factor, ranging from 10 for any water to 100 for waters where commercial fisheries are active.

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\* Information obtained through verbal communication.

#### 4. EFFECTS OF MERCURY DISCHARGES

The following notes cover topics discussed by the author with various officials and scientists.

##### 4.1 National Survey of Mercury Pollution in Japan [3]

In 1974, the Environment Agency released the results of a national survey on mercury pollution in water, sediments and fish.

- i) Water [3, 4] - Approximately 3,800 water samples, from more than 600 areas, were analyzed and found to be generally below the environmental quality standard of 0.5 ppb total mercury. Two percent of the samples, collected in areas where sediments have shown high mercury levels, were above the standard.
- ii) Sediments [3, 4] - Approximately 5,200 sediment samples, from more than 600 areas, were analyzed and found to be below the provisional standard for removal set at 25 ppm. Approximately two percent of the samples, from the bays of Minamata and Tokuyama, were found to be above the provisional limit.
- iii) Fish [5] - Approximately 22,500 fish samples, from 300 different areas, were collected and analyzed. The majority of the samples showed mercury within the prescribed limit (0.4 ppm total Hg), with the exception of fish from the Minamata and Tokuyama areas, where fishing has been banned.

##### 4.2 Dredging of Contaminated Sediments

Once it has been established that the sediments in a given area should be removed, there are three basic steps to be followed in the removal operation:

- i) Surveillance - Before starting any removal work, a network of monitoring points is established around the working area and the disposal site. Parameters to be analyzed are established and values are assigned to each parameter to indicate the levels at which removal should be suspended. Surveillance may include total Hg, turbidity, COD, pH, etc.



- ii) Removal - The method of removal of the sediments is left open to choice, as long as the surveillance conditions are satisfied. Usually, the contaminated sediments are either removed or covered up.

Suction of sediments with solids separation at a disposal site appears to be the best removal alternative.

In the case of Minamata Bay, preliminary studies indicated that a minimum of six feet of sand would be needed to cover existing contaminated sediments and to prevent future methylation of mercury. This solution has been discarded because the additional six feet of sand would prevent navigation.

- iii) Disposal and Storage of Sediments - The sediments removed by suction, or by other means, can be settled with flocculants and the clear supernatant overflowed or pumped back. The settling area can be land filled and used for such purposes as recreational facilities.

This technique has been used in the bays of Tokuyama and Dokai, where the mercury contaminated sediments were removed by suction.

Plans are being made to dredge the bay of Minamata in the near future. An engineering proposal [6, 7] has been completed and is waiting for approval and allocation of funds. It is estimated that the dredging alone will cost \$40,000,000.

Because no land is available for ponding around Minamata, approximately 2,100,000 m<sup>2</sup> of bay will be diked and used as a pond. The area to be diked has the highest mercury levels and, at the end of the operation, will be land filled. New port facilities will be built in the bay at an additional cost of \$20,000,000.

It is worth noting that, during the experimental work done in connection with dredging studies, it has been shown that chlorides interfere with the process of methylation. Other work has indicated that the addition of domestic sewage, industrial wastewater and acetic acid enhances the methylation of the sediments. Published material describing these studies was not available.

#### 4.3 Relationship Between Mercury Levels in Fish and Sediments

Sediments and fish in Tokuyama and Minamata Bay have been studied by Dr. H. Nisimura of the University of Tokyo [8, 9]. The bays were subdivided into sampling regions with similar levels of mercury in sediments. Plankton, "stationary" fish and "non-stationary" fish from each region were sampled and analyzed for total mercury.

The results showed a correlation between levels of mercury in sediments and total mercury in stationary fish.

The graph in Figure 1 shows the results from the Tokuyama Bay experiments [8].

#### 4.4 Mercury in Hair of Indians from the Kenora Area

The following information was obtained from Dr. Y. Takizawa of the Akita University School of Medicine. Dr. Takizawa has been in charge of a number of research projects concerning mercury poisoning in the Niigata area. He also represented Japan on the Organization for Economic and Cultural Development's working party on mercury in 1972/73.

Hair samples from 18 Indians living in the Kenora area were brought to Dr. Takizawa for analysis, by Mr. Ui. With two exceptions (51 and 44 mg/kg total Hg), all the samples were well below 40 mg/kg.

In the opinion of Dr. Takizawa, these data do not justify Dr. Harada's statement at the International Congress (Section 2.2) that the Indians sampled were suffering from Minamata Disease. He suggested that further sampling be carried out, together with preparation of accurate dietary histories.

He also pointed out that, in comparison, hair from Niigata patients showed total mercury levels in the order of 250 mg/kg.

#### 4.5 Minamata Disease and Chlor-Alkali Plants

One of the arguments often heard in Canada regarding mercury poisoning is that Minamata Disease is associated with acetaldehyde plants, where Hg is used as a catalyst and becomes methylated. This statement has been supported by claims that no Minamata Disease has been found in Japan in the proximity of chlor-alkali plants.



Sampling Regions = A,B,C,D,E,F  
 "Stationary" Fish =  $\blacktriangle$   $\bullet$   $\perp$   $\times$   
 Clams =  $\otimes$   
 "Non-stationary" Fish =  $\odot$   $\circ$

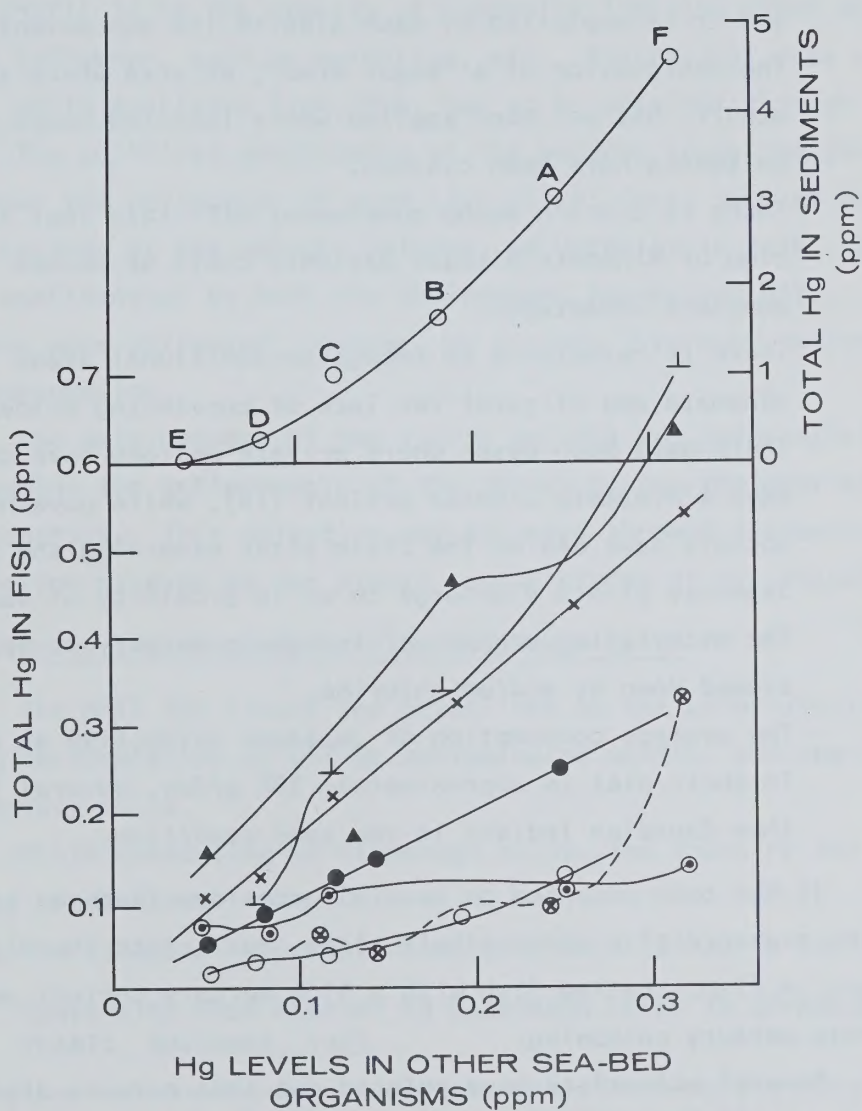


FIGURE 1 RELATIONSHIP BETWEEN Hg IN FISH AND SEDIMENTS IN TOKUYAMA BAY (8)

Because Minamata Disease is such a controversial issue in Japan, and public reaction is so extreme, no clear cut conclusion on this question has been reached. The following considerations should be kept in mind in attempting to understand how this question has been handled in Japan:

- Minamata Disease has become a hot political issue in Japan and it is exploited by each side to its own advantage.
- The designation of a "Kogai area", an area where an epidemic occurs, has not been applied where isolated cases of mercury poisoning have been claimed.
- There is concern among government officials that the designation of Minamata Disease patients could be abused to obtain monetary advantages.
- There is reluctance to recognize additional areas (in addition to Minamata and Niigata) for lack of convincing evidence.
- There have been cases where private doctors have claimed to have a Minamata Disease patient [10], while government doctors have denied the claim after examining the patient.
- Japanese plants discharge to or in proximity of sea water. The methylation process of inorganic mercury is apparently slowed down by sodium chloride.
- The average consumption of Japanese using fish as a staple in their diet is approximately 200 g/day, several times lower than Canadian Indians in the same conditions.

It has been asserted on several occasions that the key issue is not the presence of a chlor-alkali plant, but rather the high level of mercury in fish. Eating fish with a high mercury content would, in turn, cause mercury poisoning.

Several scientists have pointed out that mercury discharged by Japanese chlor-alkali plants is less available for methylation due to the effect of sea water. In addition, the rate of self-cleansing of sediments in sea water could be higher than in cold fresh water.

No Japanese, either government official or private scientist, has given any support to the theory that Minamata Disease is associated only with acetoaldehyde plants.



## 5. MERCURY POLLUTION AND CHLOR-ALKALI PLANTS

### 5.1 General

All chlor-alkali producers in Japan are members of an association (JASA) which, in the past, had a strong coordinating role in technical and marketing practices. While technical knowledge is still shared through the association, the Ministry of International Trade and Industry (MITI) is in the process of gradually limiting other aspects of JASA's influence, such as marketing, etc. Statistical data on the industry, while available from JASA, had to be obtained through MITI.

The political sensitivity of the mercury issue and the new role of MITI made the collection of some statistical data, such as Hg purchase records or the mercury balance, an unrealistic task. Such data are kept confidential by both the Environment Agency and MITI. Good indications were collected, however, on present "average" national mercury consumption.

The main purpose of the visits to JASA and chlor-alkali plants was to examine the achievements of the plants having the most advanced mercury controls. This objective was achieved through discussions, the collection of data at two plants, and pictures of the installations.

### 5.2 Conversion from Mercury to Diaphragm Cells

The MITI has issued two guidelines to the chlor-alkali industry, requiring recirculation of all Hg contaminated waters, and phasing out of the mercury cells.

While converting to diaphragm cells, the industry has also been increasing production.

The status of the conversion program is given in Table 2 below.

TABLE 2. CONVERSION FROM MERCURY TO DIAPHRAGM CELLS IN JAPANESE CHLOR-ALKALI PLANTS, NOVEMBER, 1975.

| Date        | No. of Plants | Mercury Cells                     |                    |       | Diaphragm Cells |                    |       | Total NaOH Production |       |
|-------------|---------------|-----------------------------------|--------------------|-------|-----------------|--------------------|-------|-----------------------|-------|
|             |               | No. of Plants                     | 100% NaOH Produced |       | No. of Plants   | 100% NaOH Produced |       |                       |       |
| Before 1973 | 52*           | 49                                | 3,660,000          | Mt/yr | 8               | 1,178,000          | Mt/yr | 3,883,000             | Mt/yr |
| Sept. 1975  | 52*           | 37                                | 2,837,000          | "     | 25              | 1,494,000          | "     | 4,331,000             | "     |
| March 1976  | N.A.          | N.A.                              | 1,772,000          | "     | N.A.            | 2,659,000          | "     | 4,431,000             | "     |
| March 1978  |               | expected completion of conversion |                    |       |                 |                    |       | 5,500,000             | "     |

\* Some plants have both mercury and diaphragm cells in the same location.

N.A. - not applicable

While officially scheduled for completion by March 1978, the conversion to diaphragm cells may be affected by the following considerations:

- A new technology is in an advanced stage of development (see below) for production of caustic and chlorine with an ion exchange method.
- There are plants, e.g. Okayama Chemicals, which have attained a considerable degree of control over their mercury losses. It is felt that their conversion to diaphragm cells could be over-restrictive.
- Public sensitivity over Minamata Disease and the possibility of mercury leaks make a change of the guideline a difficult political decision.

### 5.3 Financial Assistance for Conversion

The Japan Development Bank gives loans, at rates 1% less than current interest levels, for 35 to 70% of the capital cost of conversion.

From a taxation point of view, capital investments are subject to a three year depreciation, versus seven years for normal investments in the chemical industry. An additional benefit has been provided by the reduction of "plant taxes" by 50% over the first three years of conversion.

### 5.4 Ion Exchange Process

ASAHI Chemicals has, since April 1975, produced 100 Mt/yr of caustic with its new ion exchange technology. The caustic solution obtained is at 20% NaOH and it is expected to reach the 50% concentration. The 20% solution contains 0.0009% to 0.004% NaCl, compared with 0.002% produced with mercury cells.

Capital and operation costs are apparently lower than for the diaphragm cells. Figures are not yet available because the process is still at a development stage, with marketing expected to begin in September-October 1976.

Another ASAHI Company, ASAHI Glass, is also working on a 100 Mt/yr installation using ion exchange.



### 5.5 Mercury Consumption, Losses and Balance

As mentioned above, statistical data on purchases and consumption could not be collected.

An additional problem encountered in discussing mercury consumption and losses was one of terminology, as the Japanese tended to identify mercury consumption with the sum of identified and measured losses. In Canada, consumption is defined as the difference between mercury purchased and mercury added to the cells inventory.

With one exception, at Okayama Chemicals, no meaningful discussion on mercury balance could be carried out because of the absence of statistics on Hg purchases.

Despite the obvious difficulties, it was possible, from discussions with various officials, to draw a table of mercury consumed by Japanese chlor-alkali plants. The data are approximate but should closely represent the overall situation.

TABLE 3. APPROXIMATE Hg CONSUMPTION AND LOSSES BY JAPANESE CHLOR-ALKALI PLANTS

|                      | Hg Consumption<br>(charged to cells) |                              | Total Hg Losses<br>Monitored |                |
|----------------------|--------------------------------------|------------------------------|------------------------------|----------------|
|                      | g/t NaOH <sup>*</sup>                | lb/short ton Cl <sub>2</sub> | g/t NaOH <sup>*</sup>        | lb/short ton C |
| Average during 1973  | 100 to 110                           | .225 to .248                 | N.A.                         | N.A.           |
| Average during 1974  | 30 to 40                             | .067 to .090                 | N.A.                         | N.A.           |
| Average during 1975  | 20 to 40                             | .045 to .067                 | N.A.                         | N.A.           |
| 20 Companies in 1974 | <10                                  | <.0225                       | N.A.                         | N.A.           |
| 20 Companies in 1975 | 10 to 40                             | .0225 to .090                | N.A.                         | N.A.           |
| Okayama Chemicals    | 10                                   | .0225                        | 1.5                          | .0034          |
| Kashima Chemicals    | N.A.                                 | N.A.                         | 1.25                         | .0028          |
| Chiba                | N.A.                                 | N.A.                         | 2.5                          | .0056          |

\* 100% NaOH

The Japanese do not make any allowance for mercury "unaccounted for". When questioned about the difference between mercury charged to the system and measured losses, they stressed the effect of amalgamation of mercury on metallic parts of the plant and its accumulation in dead corners of the system.

Tests carried out by Prof. Matsuno of Yokohama National University have revealed that, on the average for all the plants visited, the mercury distribution is as follows [11]:

- 25% to amalgamation and accumulation in piping;
- 25% loss through concrete floors;
- 25% to wastewaters, evaporation, products and brine purification; and,
- 25% to solid waste.

The rate of amalgamation is higher in new plants than old plants.

## 5.6 Description of Hg Control Measures Taken at Okayama Chemicals Co. Ltd.

### 5.6.1 General

The plant, located in the middle of an industrial complex, has the following main characteristics:

- start up 1969;
- 32 DeNora cells, stable anodes;
- production: approximately 120,000 t NaOH/yr;
- power source: diesel generators, 5,500 kw x 11 sets;
- rated amperage 306 ka.

The plant complied with the MITI directive requiring no process water discharge and incorporated other mercury pollution control measures into its original design. The cost of all controls and monitoring equipment is estimated at \$2,000,000 in 1975 dollars.

On the whole, the measures taken at Okayama Chemicals represent the best available technology existing in Japan for the limitation of mercury losses to the environment from mercury cells plants. The company is planning to market its technology. For this reason, while most of the discussion and the visit were open, some technical details were of confidential nature and could not be obtained. The company is using special towers, called MR towers, as polishing steps for both gases and wastewaters. The MR towers contain a special proprietary resin and the level of mercury after this treatment is said to be at or below  $0.0005 \text{ mg/m}^3$  for gases.



Controls are essentially applied to mercury losses to water, atmosphere, solid wastes and products.

#### 5.6.2 Control of water pollution

The principle concept consists of the segregation of all mercury contaminated waters, including storm water, and their recycle into the brine system. The depleted brine is then evaporated to maintain the water balance.

The effluent presently discharged to the river contains wastewaters such as cooling waters from diesel generators, indirect coolers and cooling tower blow-down. Its volume is between 30 and 40 m<sup>3</sup>/hr. Before discharge, suspended solids are settled and pH corrected if necessary. In addition, an in-line continuous mercury analysis warns the operator in the control room when mercury in the effluent is above 0.5 ppb. When this occurs, the total effluent is contained and recycled to the brine system. Under normal circumstances, the mercury content of the effluent discharged to the receiving waters ranges from 0.1 to 0.3 ppb.

Simplified schemes of the wastewater treatment system are shown in Figures 2 and 3.

All storm water from the plant is segregated and treated for mercury. The plant area is divided into two parts for the purpose of segregation. The first, of approximately 4,500 m<sup>2</sup>, includes the cells-room building, the power generators, the brine, chlorine and hydrogen areas, and other areas where mercury contamination of storm water can be expected. Runoff from this area is directly recycled to the spent brine system.

The second, of approximately 9,500 m<sup>2</sup>, includes roads, piping racks and other areas where mercury contamination of storm water should not occur. Runoff from this second area is collected into a series of large concrete pits, filtered, purified through an MR tower to remove traces of mercury and either re-used as service water or recycled to the spent brine system.

Experimental work on storm water has shown that the average mercury content of the first 15 mm of rain is 20 ppb. After the first 15 mm, the Hg content reduces to approximately 1.0 ppb. No problems have been experienced with either pH or free chlorine.

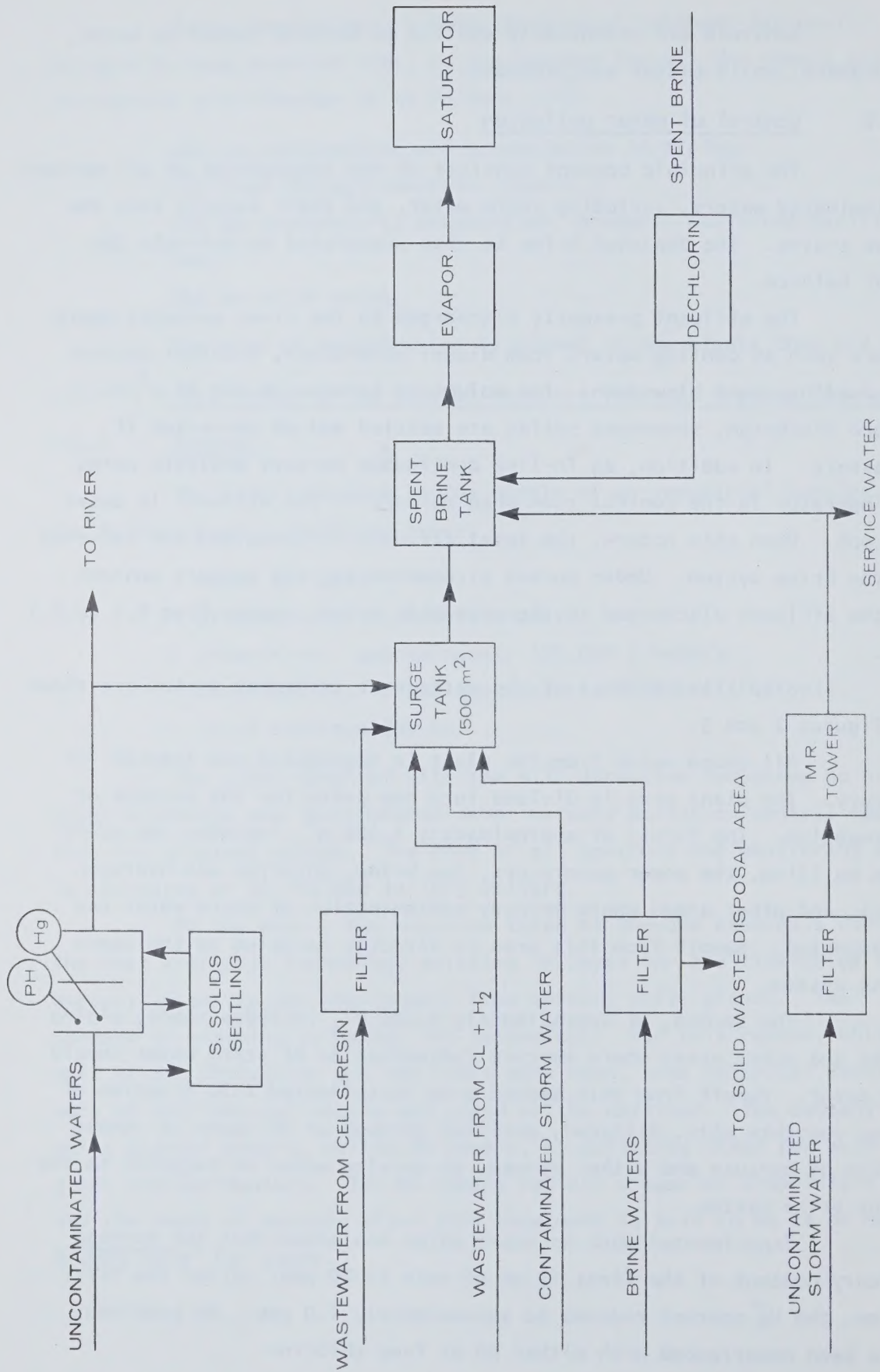


FIGURE 2. SIMPLIFIED SCHEME OF WASTEWATER MANAGEMENT AT OKAYAMA CHEMICALS CO. LTD.



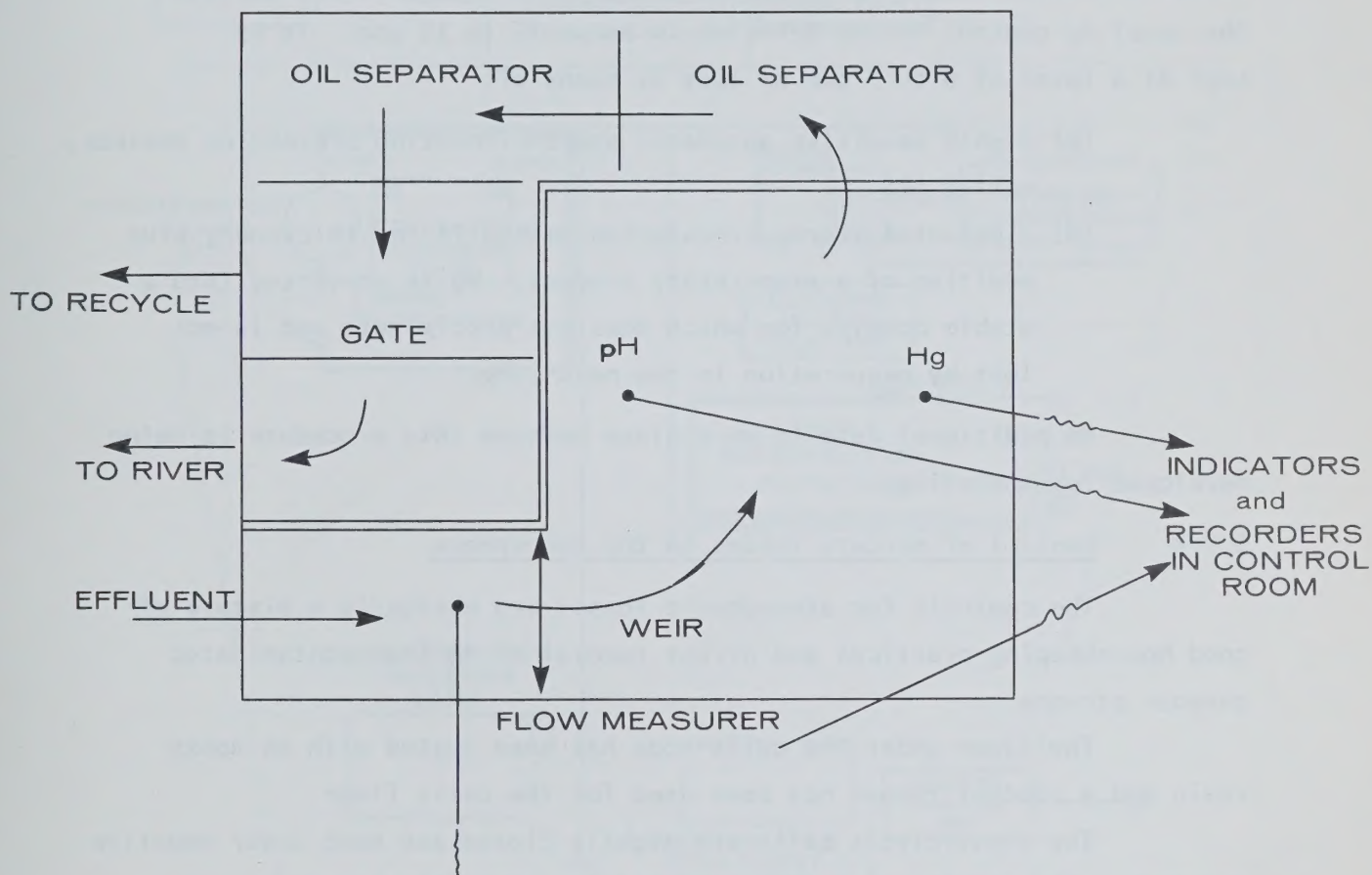


FIGURE 3. CONTROLS BEFORE FINAL EFFLUENT DISCHARGE, OKAYAMA CHEMICALS CO. LTD.

The annual maximum rainfall at Okayama is 1,250 mm, the daily maximum is 100 mm. The plant has been designed for 120 mm/day.

A general layout of the plant and wastewater system, as supplied by the company, is shown in Figure 4.

#### 5.6.3 Mercury in brine

Brine sludges are filter-pressed before going into the solidification plant. The company claims that, without special precautions, the usual Hg content in the Brine would be at 15 to 25 ppm. It is kept at a level of 6 to 7 ppm or less by means of:

- (a) highly sensitive automatic short-circuiting prevention devices, called APS.
- (b) a patented slurry circulation method in the thickener, plus addition of a proprietary product. Hg is converted into a stable complex ion which does not precipitate and is not lost by evaporation in the next steps.

No additional details were given because this procedure is being developed for marketing.

#### 5.6.4 Control of mercury losses to the atmosphere

The controls for atmospheric losses are basically a mixture of good housekeeping practices and direct removal of Hg from contaminated gaseous streams.

The floor under the cells-room has been coated with an epoxy resin and a special rubber has been used for the cells floor.

The electrolysis cells are tightly closed and kept under negative pressure. The resulting gases are washed in a hypochlorite tower and then absorbed through an MR unit. Residual mercury is said to be less than  $0.005 \text{ mg/m}^3$ . The equipment kept under negative pressure includes the end boxes, the caustic exit of the decomposer, caustic receiver tanks and end box washing water receiver tank.

Because of the controls applied to prevent short-circuiting, metallic anodes are replaced every 15 to 18 months and cells are overhauled once or twice a year. This decreases the amount of mercury lost during cells overhauling.



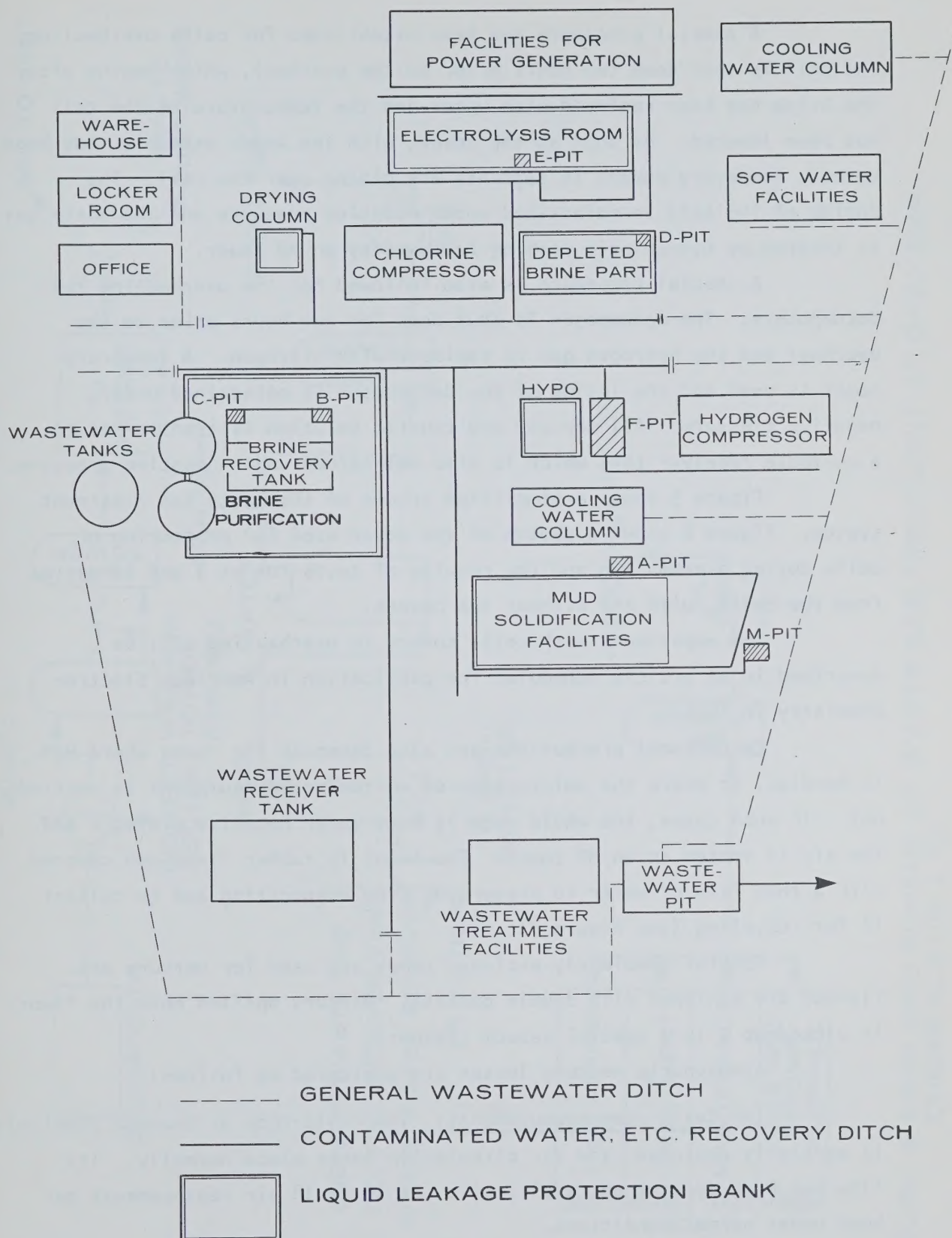


FIGURE 4. LAYOUT OF OKAYAMA CHEMICALS PLANT

A special procedure has been established for cells overhauling. The cell is shut down two hours prior to the overhaul, which begins after the brine has been replaced with water and the temperature of the cell has been lowered. As soon as the cover, with the anode assembly, has been opened, temporary covers in segments are placed over the cell. The inside of the cell is maintained under negative pressure and the waste gas is treated by hypochloric washing followed by an MR tower.

A special procedure is also followed for the overhauling the decomposers. The decomposer is shut down for two hours prior to the overhaul and the hydrogen gas is replaced with nitrogen. A temporary cover is used and the inside of the decomposer is maintained under negative pressure. All mercury and caustic solution is transferred to a portable receiver tank which is also maintained under negative pressure.

Figure 5 shows a simplified scheme of the waste gas treatment system. Figure 6 shows a sketch of the cover used for protection of cells during overhauling and the results of tests run at 3 and 10 metres from the cells, with and without the covers.

The experience with cells covers in overhauling will be described in an article scheduled for publication in American Electrochemistry in 1976.

Exceptional precautions are also taken in the rooms where Hg is handled, or where the maintenance of contaminated equipment is carried out. In such cases, the whole room is kept under negative pressure and the air is vented to an MR tower. The floor is rubber lined and covered with a thin film of water to prevent Hg from evaporating and to collect it for recycling (see Figure 7).

Special completely enclosed pumps are used for mercury and flanges are equipped with double gaskets. Mercury spilled onto the floors is picked-up with a special vacuum cleaner.

Atmospheric mercury losses are monitored as follows:

(a) Cells-room measurements: The cells-room at Okayama Chemicals is partially enclosed, and air circulation takes place normally. Its flow has been determined, empirically, as 15 to 18 air replacements per hour under normal conditions.



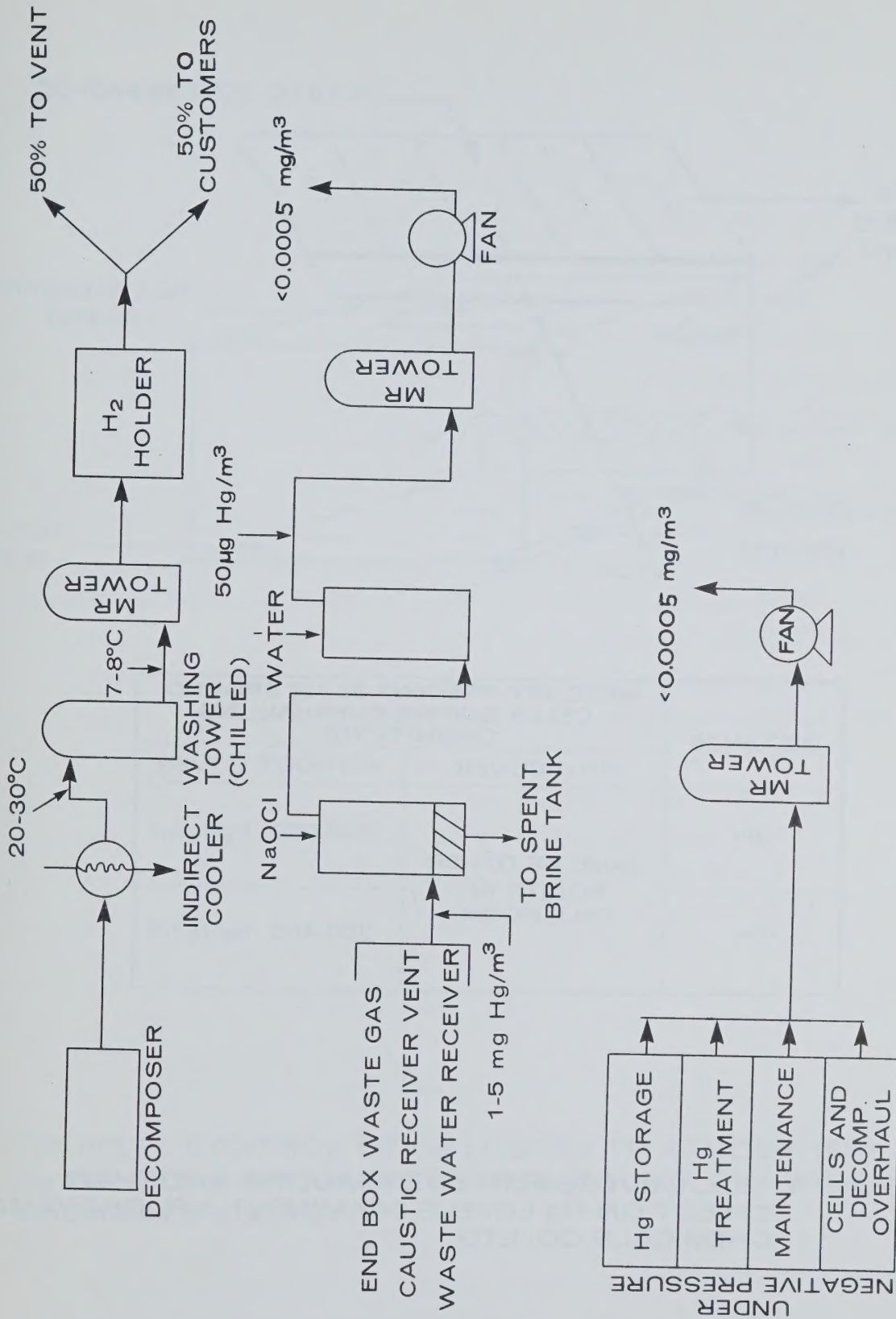
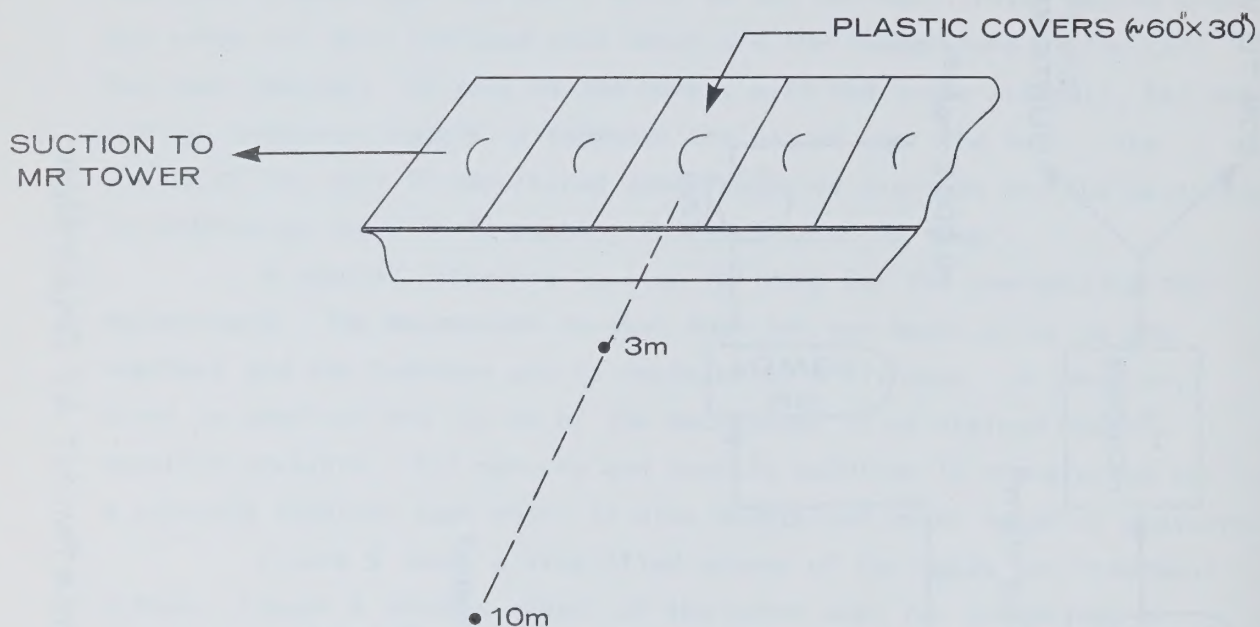


FIGURE 5. SIMPLIFIED SCHEME OF WASTE GAS TREATMENT AT OKAYAMA CHEMICALS CO. LTD.



| DISTANCE | MERCURY PRESENT IN AIR AROUND CELLS DURING OVERHAULING OPERATIONS |                              |
|----------|-------------------------------------------------------------------|------------------------------|
|          | WITH COVER                                                        | WITHOUT COVER                |
| 3m       | SAME AS OTHER POINTS IN CELL ROOM                                 | 600-900 ngHg/m <sup>3</sup>  |
| 10m      |                                                                   | 200-400 ngHg /m <sup>3</sup> |

FIGURE 6. CELL COVERS FOR OVERHAULING AND THEIR EFFECT ON Hg LEVELS IN AMBIENT AIR, OKAYAMA CHEMICALS CO. LTD.



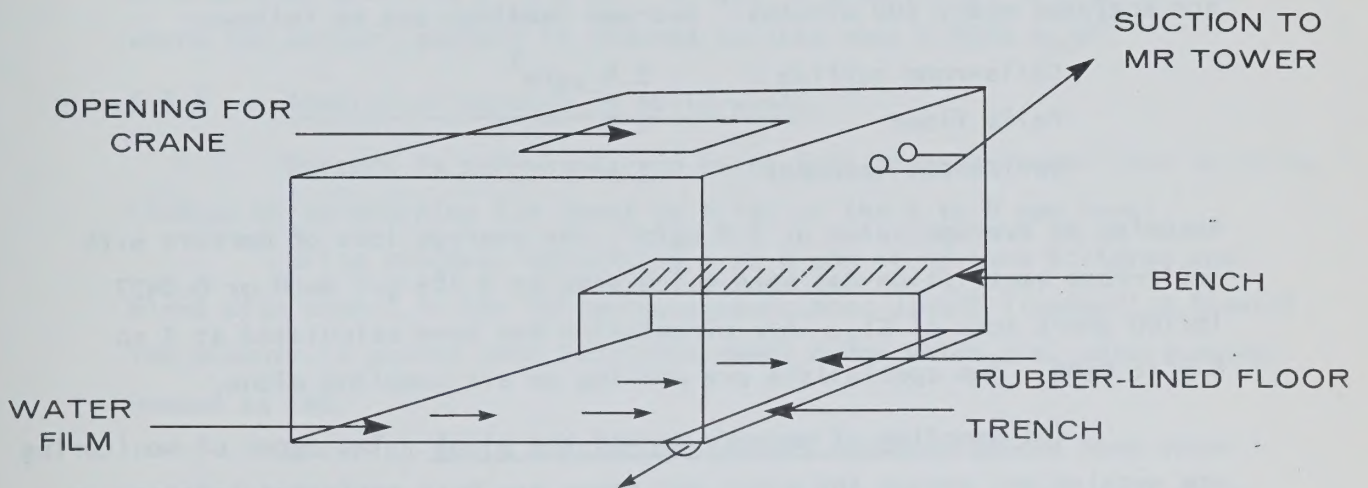


FIGURE 7. CONTROL OF Hg LOSSES TO ATMOSPHERE INSIDE Hg HANDLING AND MAINTENANCE ROOMS, OKAYAMA CHEMICALS CO.LTD.

Due to the shielding effect of adjacent buildings, wind velocity is within 1 to 2 m/sec.

In the cells room 22 points have been established at the level of the roof, the cells and the floor below. At each point, air is pumped through a permanganate solution at the rate of 4 l/sec. All 22 samples are analyzed every 100 minutes. Average readings are as follows:

|                     |                              |
|---------------------|------------------------------|
| Cells-room ceiling  | 2.4 $\mu\text{g}/\text{m}^3$ |
| Cells floor         | 1.5 "                        |
| Cells-room basement | 1.4 "                        |

Assuming an average value of  $5.0 \mu\text{g}/\text{m}^3$ , the average loss of mercury with cells-room ventilation has been calculated at 0.189 g/t NaOH or 0.0427 lb/100 short tons of  $\text{Cl}_2$ . Air circulation has been calculated at 3 to  $4 \text{ m}^3/\text{t NaOH}$ . Two specialists are working on air sampling alone.

(b) Sampling of mercury around the plant: Two types of monitoring are carried out around the plant and these are both performed independent of its operation.

- 1) Hg levels are measured at fixed points around the plant. Measurements are taken at 12 locations at the factory fence, where permanent sampling stations have been installed. The results supplied show that the concentration of mercury has very seldom been above  $0.2 \mu\text{g}/\text{m}^3$ . Unfortunately, no information was available on the frequency of this test.
- 2) Hg levels are measured downwind of the plant. Measurements are taken, downwind, at various distances and the results supplied show that the background level of  $0.05 \mu\text{g}/\text{m}^3$  is reached within 200 meters from the plant.

#### 5.6.5 Control of mercury content in products

(a) Caustic soda: The caustic solution generated in the decomposer is first cooled to  $60^\circ\text{C}$  and then filtered continuously through a vertical leaves precoat filter. There are two precoat filters of  $30 \text{ m}^2$  each arranged in parallel. The precoat material is animal charcoal and the company claims that the mercury content in the filtered caustic averages less than 0.01 ppm.



(b) Chlorine gas: Chlorine gas is first passed through a demister, then washed with water in two stages. Demister drainage and wash water are recirculated to the brine system.

(c) Hydrogen gas: The hydrogen gas from the decomposer is cooled, indirectly, to 20 to 30°C. The next stage consists of washing with chilled water to 7 to 9°C. The gas is then passed to a MR system where the mercury content is reduced to less than 0.0002 mg/m<sup>3</sup>.

#### 5.6.6 Control of mercury in solid waste

Mercury is prevented from being lost in large quantities to brine sludges by maintaining its level in brine at the 6 to 8 ppm level.

Brine sludges, containing 6 to 8 ppm of Hg, are filtered and mixed with cement in the following proportions: 3(mud):1(cement):0.8(sand). The mixture is poured into 200-litre steel drums which are, after curing, dumped at sea.

Leaching tests carried out on the concrete blocks have shown levels of mercury less than 0.001 ppm in the leachate. The steel drums are used to prevent mercury losses at the time of curing and in case of mechanical damage to the blocks themselves.

A distillation unit is used to recover mercury from activated charcoal and MR resins.

#### 5.6.7 Mercury balance

Okayama Chemicals consumes, at present, 10 grams of mercury for each ton of caustic produced. Of these, 1.5 grams are considered lost to the environment and 8.5 grams are considered amalgamated with the equipment and retained within the plant.

Table 4 shows the breakdown of mercury losses to the environment as provided by the company. Table 5 shows, again as provided by the plant, the mercury balance since 1970.

Mercury additions are presently in the order of 800 kg per year. The cells inventory of the plant is approximately 128,000 kg and it is measured by the Radio Isotopes method (Hg<sup>203</sup>) twice a year. The accuracy of such a measurement is  $\pm 1\%$  or  $\pm 1,280$  kg. It would be, therefore, a few more years before higher mercury consumption appeared as a decreased mercury inventory.

TABLE 4. MERCURY LOSSES FROM OKAYAMA CHEMICALS PLANT (g/ton 100% NaOH)

| <u>Source</u>                                | <u>Loss</u>            | <u>Remarks</u>                                                                                                                                           |
|----------------------------------------------|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. To wastewater.                            | 0.000                  | Completely closed system. Various wastewaters are recovered into brine through the wastewater treatment system using ion exchange resin and MR.          |
| 2. To atmosphere.                            |                        |                                                                                                                                                          |
| - Cell room ventilation.                     | 0.189                  | Hg concentration: $0.005 \text{ mg/m}^3$ .<br>(Average of measurement: $0.0025$ )<br>Air circulation:<br>$3 - 4 \times 10^4 \text{ m}^3/\text{t NaOH}$ . |
| - $\text{H}_2$ gas (waste)                   | 0.000                  | Hg conc. in $\text{H}_2$ gas:<br>$0.0001 \text{ mg/m}^3$ or less.                                                                                        |
| - End box vent.                              | 0.000                  | Hg conc. in waste gas:<br>$0.001 \text{ mg/m}^3$ or less.                                                                                                |
| 3. In production.                            |                        |                                                                                                                                                          |
| - $\text{H}_2$ gas.                          | 0.000                  | Hg conc. in $\text{H}_2$ gas:<br>$0.0001 \text{ mg/m}^3$ or less.                                                                                        |
| - NaOH.                                      | 0.021                  | Hg in caustic solution: $0.01 \text{ ppm}$ .<br>or less.                                                                                                 |
| - $\text{Cl}_2$ gas.                         | 0.000                  |                                                                                                                                                          |
| 4. Brine sludge.<br>(includes other sludges) | 0.150                  | Hg in brine sludge: $7-8 \text{ ppm}$ .                                                                                                                  |
| 5. Solid waste.                              | 1.109                  | MR for wastewater and $\text{H}_2$ gas,<br>Caustic soln. filter sludge.<br>Mercury is recovered by retorting.<br>(Recovering eff.: about 80%)            |
| Total                                        | 1.469 g/ton 100% NaOH. |                                                                                                                                                          |

Inventory has been measured by RI. method once or twice every year.



TABLE 5. MERCURY BALANCE, 1970-75, OKAYAMA CHEMICALS PLANT

| Period          | Production<br>NaOH t 97% | Amount of<br>charge kg | Consumption<br>(base of charge)<br>g/ton | Consumption<br>(discharge)<br>g/ton | Amount of<br>Discharge<br>kg | Effluent<br>kg | Sludges<br>kg | Atmosphere<br>kg | Production<br>kg | Solid<br>Waste<br>kg | Accumulation<br>in process<br>kg |
|-----------------|--------------------------|------------------------|------------------------------------------|-------------------------------------|------------------------------|----------------|---------------|------------------|------------------|----------------------|----------------------------------|
| 1970<br>(1-12)  | 14,828                   | 1,631                  | 110                                      | 8.6                                 | 138.2                        | 0              | 18.8          | 20.7             | 2                | 96.7                 | 1,492.8                          |
| 1971<br>(1-12)  | 67,920                   | 4,940                  | 72.7                                     | 8.6                                 | 581                          | 0              | 44            | 82.6             | 7.6              | 446.8                | 4,359                            |
| 1972<br>(1-12)  | 77,922                   | 2,036                  | 26.1                                     | 7.6                                 | 608.2                        | 0              | 21.4          | 110.2            | 4.3              | 472.3                | 1,427.8                          |
| 1973<br>(1-12)  | 95,443                   | 1,622                  | 17                                       | 6.8                                 | 652.4                        | 0              | 24.4          | 110.2            | 2.1              | 515.7                | 969.6                            |
| 1974<br>(1-3)   | 20,575                   | 308.7                  | 15                                       | 7                                   | 143.8                        | 0              | 4.1           | 27.6             | 0.5              | 111.6                | 164.9                            |
| 1974<br>(4-6)   | 27,272                   | 353.5                  | 13                                       | 4.5                                 | 122.6                        | 0              | 5.4           | 18               | 0.6              | 98.6                 | 230.9                            |
| 1974<br>(7-9)   | 26,810                   | 268.1                  | 10                                       | 1.8                                 | 40.1                         | 0              | 5.3           | 13.3             | 0.6              | 28.9                 | 220                              |
| 1974<br>(10-12) | 25,572                   | 255.7                  | 10                                       | 1.8                                 | 45.7                         | 0              | 4.3           | 13.3             | 0.6              | 27.5                 | 210                              |
| 1975<br>(1-3)   | 15,268                   | 148.1                  | 9.7                                      | 1.5                                 | 23.3                         | 0              | 2.3           | 4.1              | 0.3              | 16.6                 | 124.0                            |
| 1975<br>(4-6)   | 22,485                   | 218                    | 9.7                                      | 1.5                                 | 33.3                         | 0              | 3.4           | 5.1              | 0.5              | 24.3                 | 184.7                            |
| 1975<br>(7-9)   | 25,220                   | 244.6                  | 9.7                                      | 1.5                                 | 36.7                         | 0              | 3.8           | 5.1              | 0.6              | 27.2                 | 207.9                            |

The company appears satisfied with the decreasing and very low level of mercury consumption. They attribute the decrease in mercury charged to the cells to the decrease in the accumulation and amalgamation process.

From Table 4 it appears that 75% of the losses are associated with solid waste, which is incorporated into concrete blocks and disposed at sea far away from the plant.

#### 5.6.8 Comparison with Canadian plants

For the purpose of comparison, Table 6 shows mercury losses at Okayama Chemicals expressed in pounds per short ton of chlorine produced, in the format that has been adopted to analyze mercury losses and balance in Canadian plants. The table contains the data for two of the best Canadian plants as reported in 1974. It should be noted that the mercury defined as "unaccounted for" in Canada is considered in Japan as amalgamated with the equipment or accumulated in the process.

Considering the mercury added to the cells at Okayama per unit of production, one Canadian plant, FMC, had a mercury consumption in the same order of magnitude. Losses to atmosphere and products were higher at FMC, the main difference between the two plants.

A certain amount of accumulation and amalgamation takes place in any plant. The problem is that it varies from plant to plant. From Table 6 it could be speculated that such an accumulation could be, for a well controlled plant, anywhere from 0.01 to 0.02 lb/short ton  $\text{Cl}_2$ . Lack of recognition (and experimental quantification) of this accumulation has increased the amount of mercury "unaccounted for" in the records submitted by Canadian plants.

The measures taken at Okayama to prevent atmospheric emissions appear to be more sophisticated than those at FMC. At the same time, the technology applied at FMC clearly improves the control over losses with solid waste.

#### 5.6.9 Monitoring of mercury content in sediments and fish

Sediments in the bay, where wastewaters from the plant are discharged, were monitored for mercury in 1970 before the plant start-up. The maximum value found was 0.44 ppm. In September 1973, the bay was surveyed again with no indication of an increase in mercury levels. Fish were found with mercury levels below 0.1 ppm.



TABLE 6. COMPARISON BETWEEN MERCURY CONSUMPTION AND LOSSES AT OKAYAMA CHEMICALS AND TWO SELECTED CANADIAN PLANTS

|                    | CHLORINE PRODUCED (t)* | Hg PURCHASED (lb) | Hg USED                           |                                                | Hg LOSSES                                |                                        |                                     |                                          | TOTAL (lb) | Accumulated in Process/Unaccounted for (lb) |
|--------------------|------------------------|-------------------|-----------------------------------|------------------------------------------------|------------------------------------------|----------------------------------------|-------------------------------------|------------------------------------------|------------|---------------------------------------------|
|                    |                        |                   | Hg TO CAPITAL CELL INVENTORY (lb) | CHLORINE PRODUCTION (lb/t of Cl <sub>2</sub> ) | WITH PRODUCTS (lb/t of Cl <sub>2</sub> ) | WITH SOLIDS (lb/t of Cl <sub>2</sub> ) | TO WATER (lb/t of Cl <sub>2</sub> ) | TO ATMOSPHERE (lb/t of Cl <sub>2</sub> ) |            |                                             |
| Okayama Chem. 1970 | 14,042                 | 3,588             | -                                 | 3588 .2555                                     | 4 .0003                                  | 254 .0181                              | 0                                   | 46 .0032                                 | 304        | 3284 .2388                                  |
| 1971               | 64,320                 | 10,868            | -                                 | 10868 .1690                                    | 17 .0002                                 | 1080 .0168                             | 0                                   | 182 .0028                                | 1278       | 9589 .1491                                  |
| 1972               | 73,792                 | 4,479             | -                                 | 4479 .0607                                     | 9 .0001                                  | 1086 .0147                             | 0                                   | 242 .0033                                | 1338       | 3141 .0426                                  |
| 1973               | 90,384                 | 3,568             | -                                 | 3568 .0395                                     | 5 .0000                                  | 1188 .0131                             | 0                                   | 242 .0033                                | 1435       | 2133 .0236                                  |
| 1974               | 94,916                 | 2,609             | -                                 | 2609 .0275                                     | 5 .0000                                  | 628 .0066                              | 0                                   | 159 .0017                                | 792        | 1816 .0191                                  |
| (9 mos.) 1975      | 59,635                 | 1,342             | -                                 | 1342 .0225                                     | 3 .0000                                  | 171 .0029                              | 0                                   | 31 .0005                                 | 205        | 1138 .0191                                  |
| FMC 1974           | 59,334                 | 1,824             | -                                 | 1824 .0307                                     | 81 .0014                                 | 107 .0018                              | 56 .0009                            | 730 .0123                                | 974        | 850 .0143                                   |
| CLL(***)           | 34,995                 | 3,192             | -                                 | 3192 .0913                                     | 256 .0073                                | 839 .0240                              | 38 .0011                            | 1410 .0403                               | 2543       | 649 .0186                                   |

\* This value was calculated by using the following conversion factor: One metric ton of NaOH (97% pure) = .947 short tons of Cl<sub>2</sub>.

\*\* Okayama Chemicals defined the difference between mercury charged to the cells and mercury losses as mercury accumulated in the system due to both amalgamation and accumulation.

\*\*\* Dalhousie plant

### 5.7 Description of Control Measures Taken at Kashima Chemicals Co. Ltd.

The technology applied is similar to that at Okayama Chemicals and a limited amount of data was made available at a meeting with plant personnel. With this in mind, the following details are noteworthy:

- All storm water, from a surface of 57,000 m<sup>2</sup>, is collected in a single 1,500 m<sup>3</sup> pit.
- The spend brine evaporator has a capacity of 400 tons/day.
- The company claims that, after filtration with animal charcoal, mercury in caustic is less than 0.01 ppm.
- The inventory check with Radio-Isotopes does not allow for tanks and other places where Hg could settle.
- One man is employed to continuously sample water, air, solids and products for mercury content analysis.
- Water discharges are sampled every hour (grab samples).
- Losses to the atmosphere through cell-room ventilation are measured once a week.
- Losses in products are measured on a hourly basis and with every daily shipment.

Figure 8 shows a schematic of wastewater segregation as supplied by the plant. Figure 9 shows the progress in limiting mercury discharges made by the company since 1971. It should be noted that this plant defines mercury consumption as the sum of monitored mercury losses, not as the mercury added to the cells.



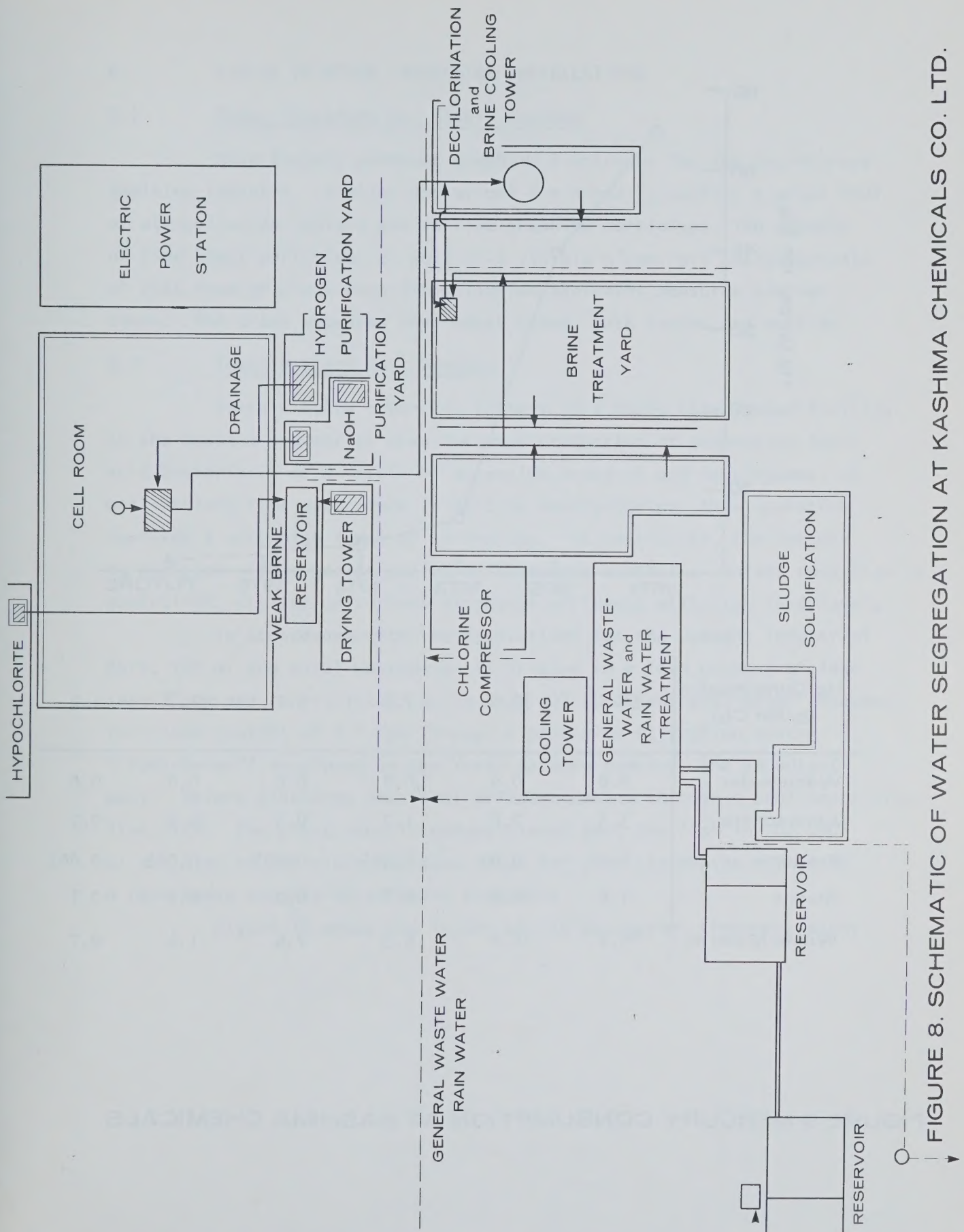
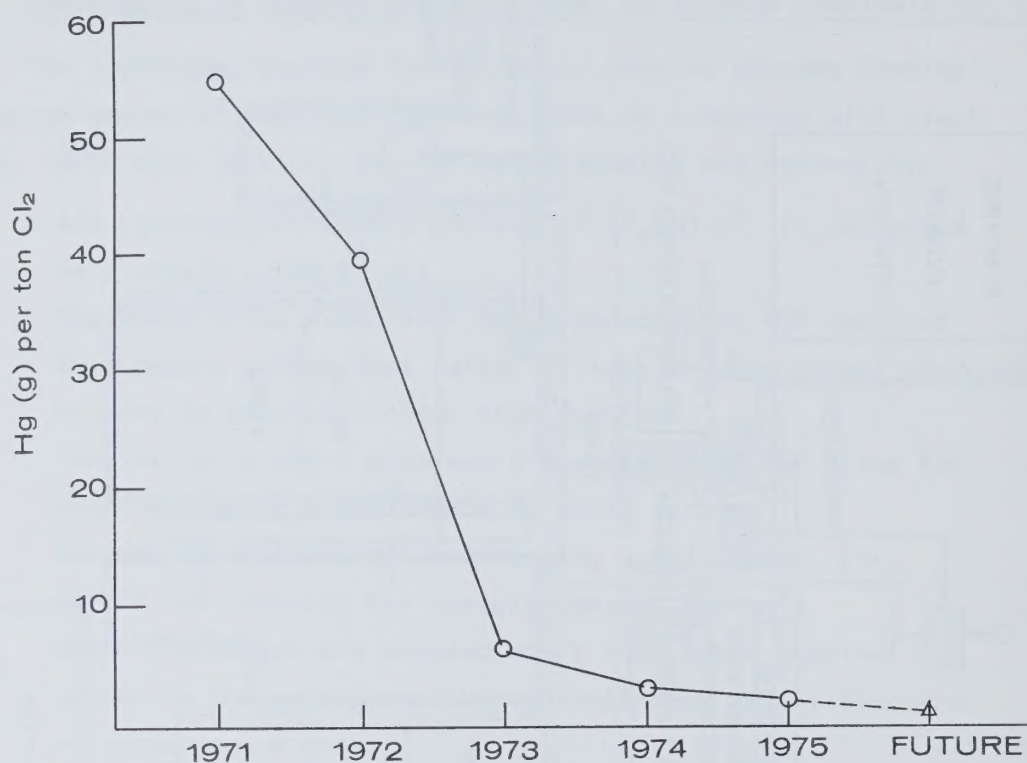


FIGURE 8. SCHEMATIC OF WATER SEGREGATION AT KASHIMA CHEMICALS CO. LTD.



| Hg Consumption<br>(g/ton Cl <sub>2</sub> ) | 54.5 | 39.5 | 7.7   | 3.1   | 1.7   | 1.0   |
|--------------------------------------------|------|------|-------|-------|-------|-------|
| Wastewater                                 | 0.0  | 0.0  | 0.0   | 0.0   | 0.0   | 0.0   |
| Atmosphere                                 | 3.3  | 2.6  | 1.2   | 0.3   | 0.2   | 0.2   |
| Products                                   | 0.01 | 0.01 | 0.005 | 0.002 | 0.002 | 0.002 |
| Sludge                                     | 1.6  | 0.5  | 0.2   | 0.2   | 0.1   | 0.1   |
| Waste Material                             | 49.6 | 36.4 | 6.3   | 2.6   | 1.4   | 0.7   |

FIGURE 9 MERCURY CONSUMPTION AT KASHIMA CHEMICALS



## 6. VISITS TO OTHER INDUSTRIAL INSTALLATIONS

### 6.1 Showa Electrode Co. (SEC), Osadano

This factory produces graphite electrodes for the non-ferrous smelting industry. Similar operations are normally causing a great deal of air pollution, mainly due to fine graphite particles. The deposit of fine black particles, as well as a visible plume, are characteristic of this type of plant when air pollution abatement measures are not taken. The plant appeared remarkably clean, both inside and outside.

### 6.2 Yuasa Battery Co., Osadano

Yuasa's Kyoto - Osadano factory is a newly established facility in the Osadano Industrial Area for mass production of automotive lead-acid batteries. As a result of extensive research and development, as well as long-time experience in battery manufacturing, this operation features a very high level of technology. In particular, the factory is equipped with superior pollution abatement controls. Unless specifically controlled, similar operations discharge effluents with high lead levels.

In accordance with the regulations for the Osadano Industrial Park, 70% of the total wastewater is treated to a lead content of less than 1 ppm and recirculated, while only 30% is discharged, after treatment to a lead content of 0.1 ppm through a precision filtration system ("Yumickener") developed by the Yuasa Battery Company, and pH adjustment. Before discharge the final effluent passes through a pool containing live fish. The plant superintendant stated that the fish in the pool at the time of the visit had been alive for over six months. This is a remarkable example of effluent treatment.

Figure 10 shows the layout of the wastewater treatment plant.

# LEGEND

BP - backwash tank  
 C1, C2 - conditioner tanks  
 F - flow meter  
 FP - filter press  
 FT - final tank  
 HS - heat source  
 L - level controller  
 M - electric motor  
 N1...N4 - neutralizing tanks  
 P - pump

P1...P4 - pH indicator controllers  
 PAC - PAC tank  
 PA1, PA2 - pH indicator controller with alarm  
 R - receiver from SF3 and U1 & U2 backwash  
 SFR - receiver from sand filter  
 SF1, SF2 - sand filter  
 T1, T2 - thickeners  
 T'1, T'2 - receiver tanks from thickeners  
 U1, U2 - "yumickeners"  
 WT - wastewater tank  
 WW - wastewater from factory

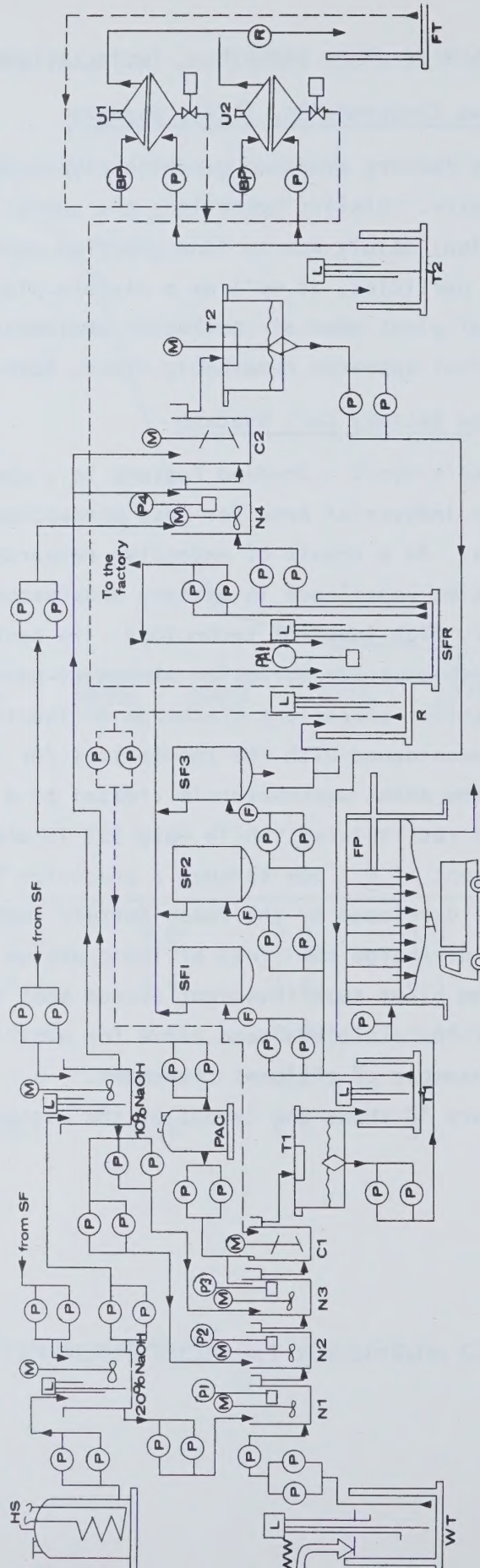


FIGURE 10 WASTEWATER TREATMENT AT YUASA BATTERY CO. LTD.



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APPENDIX I

THE CAUSE AND CHANNELS OF MERCURY  
POLLUTION IN WESTERN ONTARIO

by

Junko Nakanishi  
University of Tokyo

Paper presented at the Congress of  
Scientists on the Human Environment,  
Tokyo, Japan, November 17-26, 1975





APPENDIX I

## THE CAUSE AND CHANNELS OF MERCURY POLLUTION IN WESTER ONTARIO

by

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 Department of Urban Engineering  
 Faculty of Engineering  
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Our group visited Canada this summer for research of Minamata Disease in Western Ontario, Canada and have gained many valuable informations about mercury pollution. I want to report about the some features of the mercury contaminations in Western Ontario and the pollution source and routes on the basis of the information obtained in Canada.

## I. Pollution Map

The pollution map was obtained, shown in Fig. 1, by plotting the mercury concentration of pike\* and pickerel\*\* on the map of Western Ontario. The values of mercury concentration of two index fishes are

\* pike; The pike has been described as a mere machine for the assimilation of enormous quantities of organisms; they put on weight at the rate of a pound a year, at least.

Pike fry hug the bottom for several days after birth. They remain in shallow water for several weeks and their first food is ting water fleas and other small aquatic organisms.

They soon turn to a fish diet, for example, sucker fry batched in the area about the same time. They are cannibalistic; a pike  $1\frac{1}{4}$  inches in length will attack a pike one inch in length.

Perch, shiners and young pan fishes appear to make up a considerable portion of the diet of large pike.

Age and size of Northern pike in Ontario are 1-13 years in age, 9.2-42.1 inches in length and 0.12-14.00 pounds in weight. We have no information about the range of migration.

\*\* walleye: Young walleye feed mostly on small plankton organisms. With increasing size, aquatic insects and their larvae and numerous other invertebrates are eaten. With further growth, fish such as yellow perch, minnows, suckers and ciscoes are important food items.

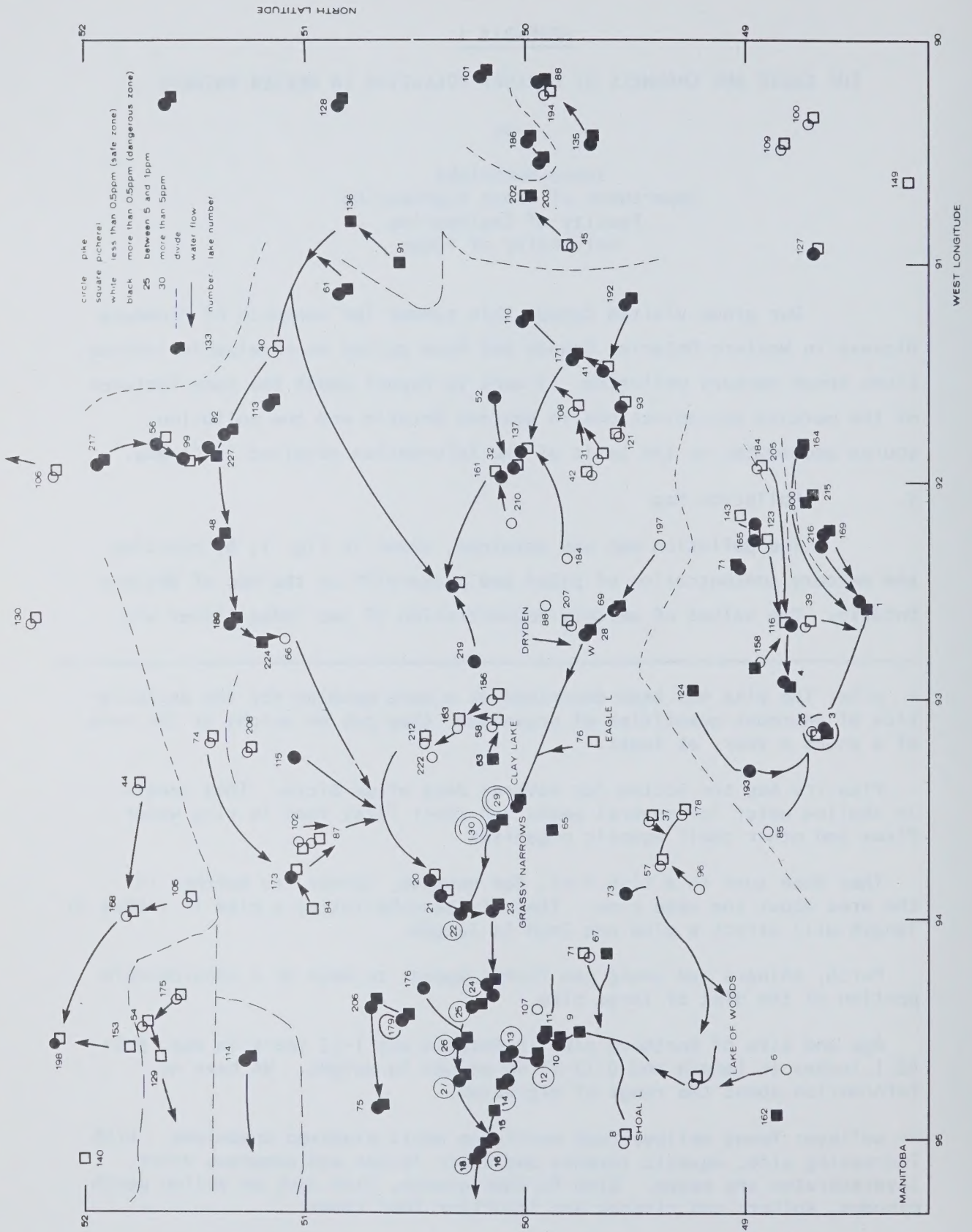


FIGURE 1. POLLUTION MAP



arithmetic mean values of results of specimens, collected until mid December in 1971, and analyzed by six organizations, Canada Department of the Environment, Toronto, and Canada Department of the Environment, Winnipeg, Food and Drug Directorate, Ottawa, Freshwater Institute, Winnipeg, Ontario Water Resources Commission, Toronto and Provincial Pesticide Laboratory, Guelph. The numbers of the tested specimens are diverse, in the case of the pike of Lake of the Woods 501 specimens, and in the case of Sand Lake only one specimen. The pollution map shows that there are some dangerous zones in which mercury concentration exceed 0.5 ppm, the safety criteria in Canada.

But the mercury level in the Wabigoon River system (Region I) is particularly high and clearly different from the other some dangerous zones (Region II). Almost all the values of mercury in the Wabigoon River system (Region I) exceed 1 ppm and those are over 5 ppm in the Clay Lake (NO. 29) and Segise Lake (NO. 30). That contrasts with the other dangerous zones, where the mercury level are between 0.5 and 1 ppm (Region II).

---

Average age and size of walleye in waters  
of Ontario and adjacent areas

| Average age<br>(years) | Average length<br>(inches) | Average weight<br>(ounces) |
|------------------------|----------------------------|----------------------------|
| 2                      | 7.4                        | 3 oz                       |
| 3                      | 10.6                       | 10 oz                      |
| 4                      | 12.3                       | 16 oz                      |
| 6                      | 15.3                       | 2 lb 3 oz                  |
| 8                      | 20.3                       | 4 lb 14 oz                 |
| 12                     | 24.1                       | 8 lb 14 oz                 |
| 13                     | 25.1                       | 10 lb 12 oz                |

It is an active swimmer and a great traveller. Tagging studies conducted on the Winnipeg River demonstrated that some walleye were caught 25 miles downstream and some 10 miles downstream upstream from the tagging site. The greater percentage was caught downstream. The period involved from the date of tagging to the date of the recovery was one to two months.

It is important to distinguish Region I from Region II, in order to make clear the pollution sources. At first the most probable source of Region II was thought to be the gold mine, in which mercury has been used by amalgam method. But we have not yet gained the clear correlation between pollution and gold mines. It is need to try to find the pollution source of Region II. The pollution source of Region I is clearly at Dryden.

## II. A survey of the mercury pollution in the Wabigoon River System (Region I)

### II-1. Fishes

The mercury concentration level of walleye (Pickerel) in the Wabigoon River system was shown in Fig. 2 (N. Fimereitte and L. M. Reynolds). The tested materials were collected between July and August in 1970. As shown in Fig. 2, the mercury value was highest in the specimens from Clay Lake (NO. 29) and became lower with the distance from Dryden. Between Dryden and Clay Lake no walleye occurred. Surprisingly the mercury level in Clay Lake is 15.74 ppm (mean value of five specimens, average weight 1350 g), perhaps the highest in the world, and the contamination of mercury ascertained even in the specimens of Tetu Lake (NO. 16), nearly 200 miles below.

L. Hamilton surveyed mercury levels of cray fishes in Wabigoon River (Fig. 3).

The tested materials were taken in August of 1971. The effort to take samples was done but no specimens were within 30 miles from Dryden. All levels of mercury of cray fishes in English River were between 0.09 and 0.27 ppm above the junction to Wabigoon River (NO. 76) and those were between 7.36 and 0.87 ppm below the junction.

### II-2 Sediments

The mercury levels of the sediments of Clay Lake were examined by F.A.J. Armstrong, D. Metner and M.J. Capel, were between 0.1 and 7.8 ppm (dry base) and the average values of all samples was 3.1 ppm. The high values were found in the topmost 5-6 cm of the sediments. They estimated the total amount of mercury hold in the sediment of Clay Lake to be two tons, about one fifth of total discharge by Dryden Chemicals Co.



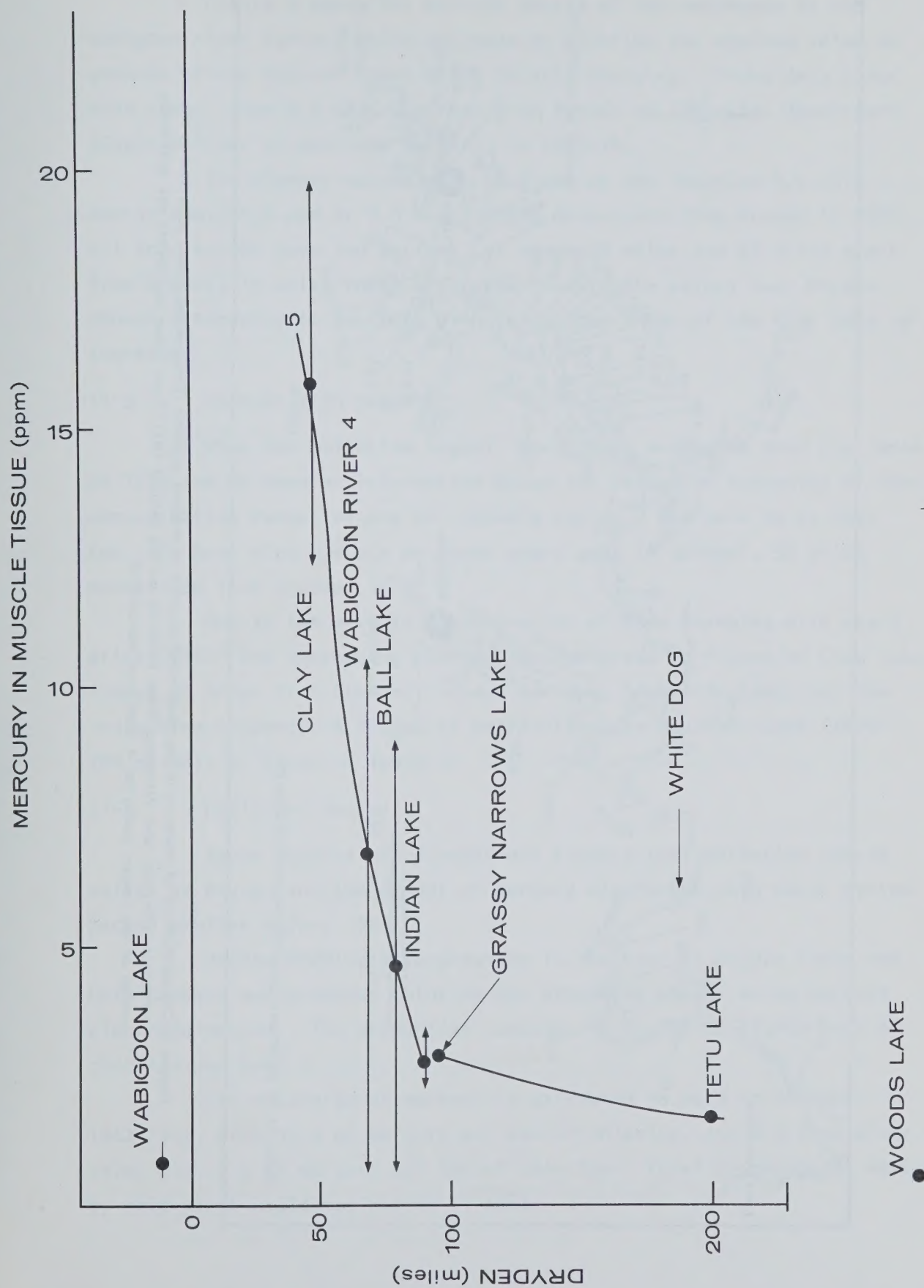


FIGURE 2. CONCENTRATION OF MERCURY IN WALLEYE

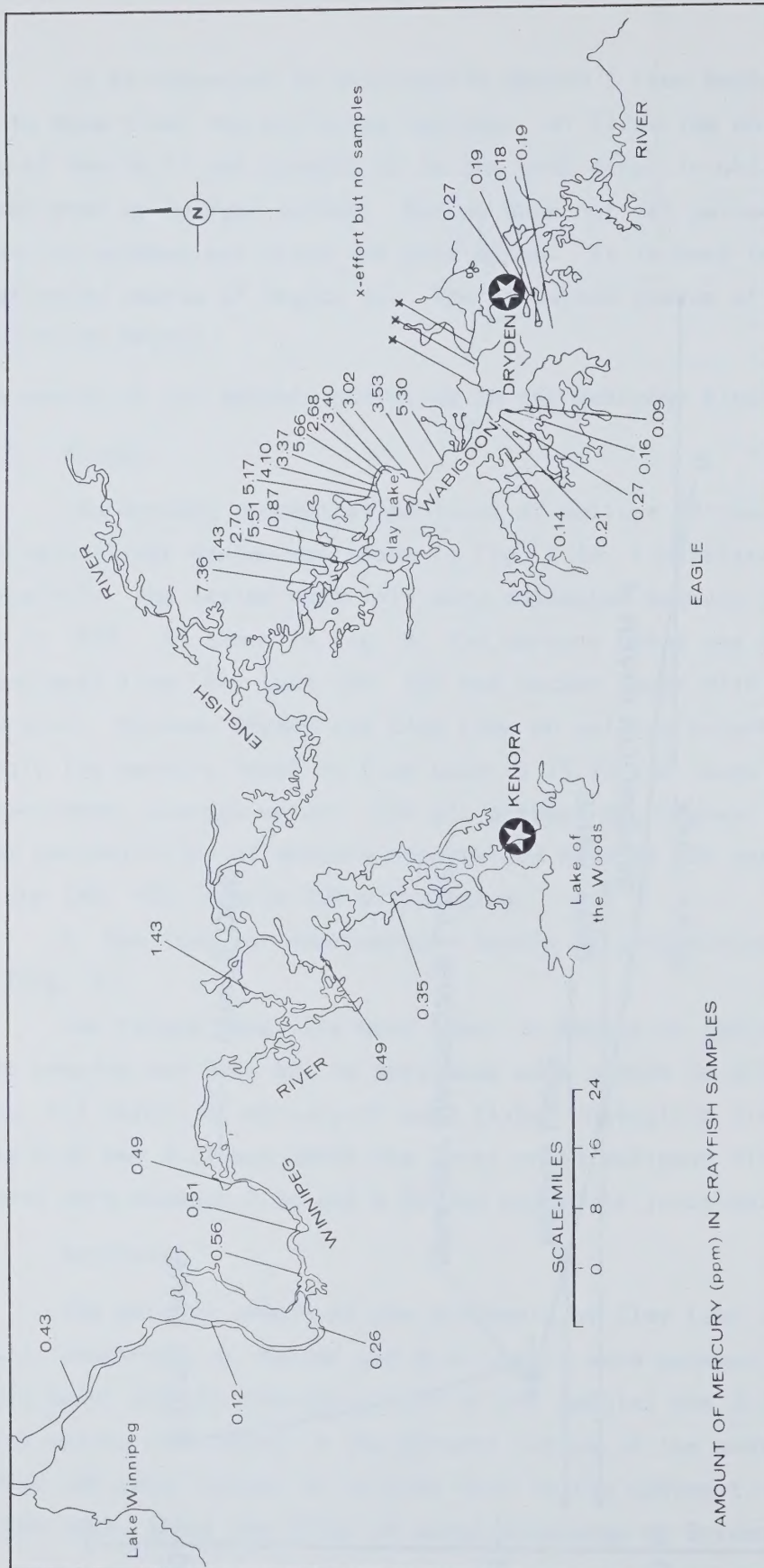


Figure 3 Concentrations of mercury in the abdominal muscle of mature crayfish (*Orconectes virilis*) collected in the Wabigoon, English, and Winnipeg River systems during August 1971. Each value represents the arithmetic mean of the values found for 4 individual specimens.



Figure 4 shows the mercury levels of the sediments in the Wabigoon river system, which was made by plotting the maximum value on grounds of the data of Grant Mill, Ontario Ministry. Those data cover wide range, from 0.5 mile upstream from Dryden to 170 miles downstream (English River at Manitoba Border), in 1970-74.

The highest values were 56.0 ppm at the location 0.5 mile downstream, 54.0 ppm at 0.9 and 3 miles downstream from Dryden in 1970. All four curves have two bottoms, at about 25 miles and 50 miles apart from Dryden, in which there are rapid flows. The values near Dryden showed a tendency to decrease with years, but those of the Clay Lake to increase.

#### 11-3 Changes with years

When the pollution began? The oldest available data are those in 1970 and we have no information about the period of beginning of mercury contamination except of one old woman's saying. She said to us that two cats have died mad six or seven years ago, in Quinbel, 30 miles downstream from Dryden.

How is the mercury concentration of fish changing with years after 1970? The decreasing tendency was observed in fishes of Clay Lake (about 50 miles from Dryden), Grassy Narrows, Separation Lake, but the increasing tendency in fishes of Umfreville Lake and Tetu Lake (about 200 miles), as shown in Table 1.

#### 11-4 Pollution source

Above results and discussions suggest that pollution source exists at Dryden and the amount of mercury discharged into water system became smaller before 1970.

Dryden Chemicals Corporation is one part of Dryden Paper and Pulp Company and produces chlorine for bleaching agent, using mercury electrode method. The productive capacity is 11,000 to 12,000 tons of chlorine per year.

The discharge of mercury is estimated to be 9 to 10 tons, 1962-1969, with 95 g of mercury per ton of chlorine, and 0.2 tons after 1970, with 3 g of mercury per ton of chlorine. Total discharge of mercury by this plant would not exceed 11 tons.

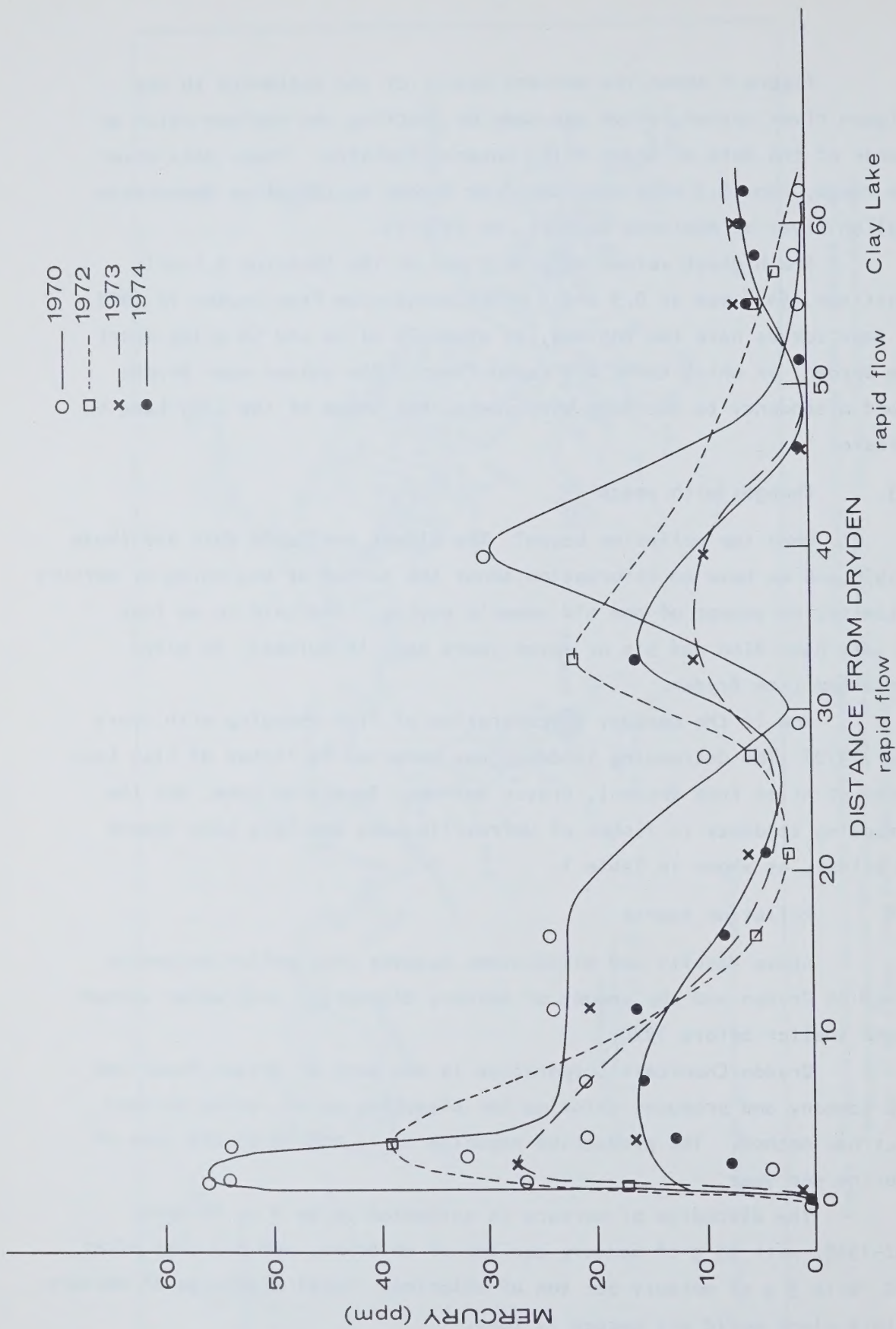


FIGURE 4. MERCURY IN SEDIMENTS



TABLE 1

Mean Mercury Levels PPM\*  
(J.M. Graham)

|                                   |          | <u>1970-71</u> | <u>1973-74</u> |
|-----------------------------------|----------|----------------|----------------|
| 1. Clay Lake<br>(5003/9330)       | N. Pike  | 9.24           | 4.22           |
| 2. Ball Lake<br>(5018/9400)       | N. Pike  | 4.00           | -              |
|                                   | Pickere1 | 2.89           |                |
| 3. Grassy Narrows<br>(5010/9419)  | N. Pike  | 4.30           | 2.98           |
|                                   | Pickere1 | 2.1            | 1.90           |
| 4. Lount Lake<br>(5010/9419)      | N. Pike  | 3.69           | -              |
|                                   | Pickere1 | 2.23           | -              |
| 5. Separation Lake<br>(5014/9424) | N. Pike  | 5.61           | 2.98           |
|                                   | Pickere1 | 3.21           | 1.90           |
| 6. Umfreville<br>(5018/9445)      | N. Pike  | 1.89           | 3.35           |
|                                   | Pickere1 | -              | 1.99           |
| 7. Tetu Lake<br>(5011/9502)       | N. Pike  | -              | 2.21           |
|                                   | Pickere1 | -              | 1.56           |

The wastewater of this plant was discharged without treatment and brine mud (sludge) was buried somewhere, 1962-1969, but since 1970, wastewater was treated by sodium sulfide, and precipitated, and brine mud was concretized.

Organic mercuric compounds as slimeicide have never been used in this company. Finally all mercury discharged by Dryden Pulp Company was inorganic mercuric compounds.

### III. Conclusion

In analyzing the many data about mercury contamination in Western Ontario. It was made clear that the pollution source of Wabigoon River system was Dryden Chemicals Co. and that the only 10 tons of inorganic mercury discharged about 5 to 15 year ago had a great potential

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\* Mercury expressed as total mercury in the edible portion of the fish.  
(0000/0000) Sample location by geographic coordinates.

N. Pike --- Northern Pike

Pickere1 --- Yellow Pickere1 or Walleye

power of pollution of sediments, of fish and of human being.

The production ability of Dryden Chemicals is only less than 1% of total production of Japan and then we must re-examine the mercury pollution by chloro-alkali plant in Japan.



APPENDIX II

LIFE OF CANADIAN INDIANS AND THE INFLUENCE OF  
MERCURY POISONING ON IT

by

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Paper Presented at the International Congress  
of Scientists on the Human Environment (HESC),  
Kyoto, Japan, November, 1975





LIFE OF CANADIAN INDIANS AND THE INFLUENCE OF  
MERCURY POISONING ON IT

by

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I. PURPOSE AND METHOD

1. Purpose

I, as a member of the second world environmental research group organized in Japan, visited two Canadian Indian reserves, Grassy Narrows and White Dog, Ontario, In August, 1975. I took charge of social research work on the influence of mercury poisoning on the lives of Indians, there.

The purpose of this social research work was, of course, the same as that of the research group which intended to prevent the spread of the number of victims of mercury poisoning. However, this research work had one more special purpose to investigate the influence of mercury poisoning on the lives and community of the Indians.

We already had knowledge of another piece of research done in 1973 from similar view-point, by the Dept. of National Health and Welfare, Canada. We thought it was good work, but we wanted to find out about the new situation in 1975, and also to gather knowledge by ourselves, as we are, regrettably, scholars in the most polluted country in the world.

2. Method and Object

Our main method was interviewing, but we tried to gather as many objective data as possible, too. We interviewed representatives or typical families chosen according to the size of the family, their way-of-life, status and whether it was a problem family. I, by myself, visited these houses and had communication with people inside their houses.

As the visiting time was only seven days for two reserves, and I was the only one interviewer, the number of houses visited was only 15. Details of them appear on Table 1.

Meanwhile, I was compelled to recognize that gathering objective data about Indian reserves was very difficult because little data had been prepared there previously. I managed to find a simple name-list about Grassy Narrows, but I looked in vain for one about White Dog. No other printed objective data was gained. Therefore, I had to spend much of my time making notes on the general situation of employment, income, the education level and details of the constitution of each family, as I heard them from an officer.

## II. GENERAL SITUATION OF THE TWO RESERVES

### 1. Geographic and Natural Condition

Both the two reserves are located in the same latitude, north latitude 50° and 100 kilometers away from each other. The nearest city to them is a small town Kenora, Ontario. The two reserves are also located in the midst of an area which includes plenty of lakes, rivers and forests. However, no road has been build between the two reserves though a water system connects them. This means that the people from both reserves have had no connection with each other.

The only way for the people to get out of their reserves, is by the road leading to Kenora city. It costs about 90 dollars to go to Kenora and back by taxi. As there are few privately owned cars in the reserves, people have to call a taxi from Kenora when they want to go there.

### 2. Population etc.

I could not even get accurate figures about population, or the constitution of families. According to the figures published by Indian Affairs, there is a population of 517 band members, of whom 416 live in Grassy Narrows and 674 band members, 563 live in White Dog as of 1972. According to an officer at the band office, about 600 people live in each of both reserves as of August, 1975.



TABLE 1. HOUSES VISITED IN AUG. 1975

| Case No. | Member | Job                                     |
|----------|--------|-----------------------------------------|
| G-1      | 10     | Guide (Summer Only)                     |
| G-2      | 2      | No                                      |
| G-3      | 9      | No                                      |
| G-4      | 12     | Hand Release Program<br>(2 Months Only) |
| G-5      | 5      | Supervisor of Building School           |
| G-6      | 7      | Project Manager                         |
| G-7      | 11     | Hand Release Program<br>(2 Months Only) |
| G-8      | 3      | Office Worker                           |
| W-1      | 2      | No                                      |
| W-2      | 2      | No                                      |
| W-3      | 8      | Health Services                         |
| W-4      | 5      | Store Keeper                            |
| W-5      | 4      | No                                      |
| W-6      | 10     | No                                      |
| W-7      | 6      | Guide (Summer Only)                     |

The number of houses is 63 at Grassy Narrows and 67 at White Dog. The number of households is 267 at Grassy Narrows, but unknown at White Dog.

Almost all the members of both reserves are Indians and only a few, such as school teachers and their families, ministers and policemen, are white people.

### 3. Institutions and Equipment

Institutions and equipment are very poor in both reserves. There are no amusement facilities, no transport facilities, very poor medical facilities and very poor communicate facilities. As for physicians, there is only one, a volunteer at Grassy Narrows, and no one at White Dog.

As for stores, there is one owned by Hudson's Bay Company at Grassy Narrows and two small ones owned by the white people at White Dog. Most people we met there told us about high-prices of things sold by the stores. However, the status of the stores in the reserves are steady because if people go to Kenora to get cheaper things, they have to pay 90 dollars for a taxi, which means worse bargain.

As for schools, there is one at each reserve, but the one at Grassy Narrows is too small and the one at White Dog is too luxurious.

Electricity finally arrived at Grassy Narrows in spring, 1975 and a water supply has been partly installed at White Dog, but not yet at Grassy Narrows.

## III. LIFE OF PEOPLE AND HISTORY OF COMMUNITY

During our visit we observed not only the poor living conditions described above, but also the material and moral desolation of the lives of people:

### 1. Situation of Employment

The employment situation as of April, 1975 was as shown in Table 2.

From Table 2, it can be seen that only a few people were employed regularly as of April, 1975 and also that this situation has been a big obstacle for maintaining the community.



TABLE 2  
 Situation of Employment of  
 Grassy Narrows and White Dog as of April, 1975

---

Grassy Narrows

|                       |             |
|-----------------------|-------------|
| Guiding (Summer Only) | abt. 20 ps. |
| Store Work            | 4 ps.       |
| Office work           | 9 ps.       |

White Dog

|                                                |             |
|------------------------------------------------|-------------|
| Cleaning School, Driver                        | 3 ps.       |
| School Teacher, Teacher's Aid                  | 2 ps.       |
| Health Worker                                  | 2 ps.       |
| Building and Repairing Houses<br>(Summer Only) | abt. 20 ps. |
| Guiding (Summer Only)                          | a few       |
| Store Keeper                                   | 2 ps.       |
| Office Workers                                 | 5 ps.       |

---

Some change has occurred in this situation since May, 1975 at Grassy Narrows. Some unique projects were proposed to the Government then and some of them were accepted. Then a few new projects began at Grassy Narrows and some more people than noted in Table 2 could get jobs.

The income of each job is as noted in Table 3.

For homes where there is unemployment, old-aged families and handicapped families, welfare has been given. However, Indian people told me that the amount of this welfare was not enough for them to live comfortably. For example, the housewife of W-6, a family with 10 members, said that she needed 500 dollars per month at least. It could be supposed that the amount of welfare is less than the ordinary income of working people.

## 2. Housing, Food and Cultural Aspects

The size and style of houses are decided by the Government as follows:

House for a Big Family; 3 bedrooms, 1 living room,  
1 kitchen, 1 storage-room.

House for a Middle Sized Family; 2 bedrooms, 1 living  
room, 1 kitchen, 1 storage-room.

However, as the number of members of a family changes constantly, this way of living was not practised when I visited the reserves this summer.

Apart from the problem of the dimensions of houses, the Indian people are not satisfied with the monotonous design, the unified style and the material of houses dictated by the Government alone, because most Indian people lived in their self-designed house in different districts where they were driven away by the Government about 15 years ago.

No bath rooms have been built in the present houses and toilets are build about 20-30 meters from the houses. In winter, which lasts about six months, it becomes minus  $40^{\circ}\text{C}$  in thse reserves. How can people use separated toilets under such strict climatic conditions?



TABLE 3

Income of Each Job (As of Aug. 1975)

| Job                     | Income               | Working Hour<br>Per Day |
|-------------------------|----------------------|-------------------------|
| Guiding                 | \$24 plus 1 meal/day | 8 hrs.                  |
| Store Work              | Unknown              | 8                       |
| Store Keeper            | \$30/day             | 13                      |
| Hand Release<br>Program | \$24/day             | 8                       |
| Fishing for<br>People   | \$20 - \$24/day      | Unknown                 |
| Building<br>Houses etc. | Over \$32/day        | 8                       |
| Office<br>Workers       | \$3,000 - 8,000/year | 8                       |

It was discovered that food was poor both in quantity and in quality. Indians used to eat mainly fish in summer and meat from wild animals in winter as an origin of protein in the days when they lived in their home villages. They could eat wild rice and vegetables they planted. Nowadays, they can't get enough wild animals because of their relocation and they can't eat fish because of mercury poisoning. They have to buy all their food from the store located in their reserves, but things sold by the store are expensive. Therefore, people can't get enough food to satisfy their needs. Most families are now suffering from starvation.

As I described above, the Indian people on both reserves are compelled to lead their lives under very poor housing conditions, food conditions and unsteady employment. The same kind of situation was found to exist with regard to the cultural situation in these reserves, too.

As for the level of education, a few people graduated or retired from high-school and some people graduated or retired from junior-high school. Most people attended only one or two grades of school. The leading people in both reserves all retired or graduated from high-school.

As for their English speaking ability, only 30 percent of the people in Grassy Narrows can speak and understand English. In this reserve, people of over 40 years only hardly understand English. They use their native language. In White Dog, it was found that most people, even old people could understand English because a lot of cases of mixing existed.

One of the main reasons why people could not finish their education is related to the contents of education. Most of what has been and is taught to Indian children has no connection with the real lives of their families or community. Children lose interest in learning things in school as soon as it begins and they drop out. If education continues in this way, there is no hope for the cultural level of the Indian people to rise.



Among all the evidence pointing to the extreme poverty on both reserves, the curious phenomenon of their furniture stands out. There were a lot of TV sets both coloured and b&w, quite a lot of electric washing machines, electric refrigerators and some electric ovens in both reserves. Can people who don't understand English understand TV programmes in English? Can an electric washing machine be used well without a water supply? Most TV sets and electric washing machines were found to be broken. The Indian people have been palmed off with these useless but expensive items from the stores in their reserves on a hire-purchase system. Now, paying for these expensive things is a big burden of the Indian people.

### 3. Historical Speciality

As for Grassy Narrows, as I noted above, relocation from its original position is the most outstanding fact. People of over about 25 still have vivid memories of their home village and their faces light up when they talk about their native land. According to them, a comparison of the old reserve and the present reserve reveals the following:

#### Comparison of Old Reserve and Present Reserve

| Old Reserve                                                            | Present Reserve                                             |
|------------------------------------------------------------------------|-------------------------------------------------------------|
| Soil was fertile.                                                      | Rocky land.                                                 |
| Vegetables grew.                                                       | Vegetables don't grow.                                      |
| Area was big.                                                          | Area is small.                                              |
| Spaces between each house were large.                                  | The space is too small.                                     |
| Houses were built by the people themselves with a feeling of creation. | Houses are built by the Government and unified, monotonous. |
| Lakes was big and scenery was marvellous                               | Lake is small, far away and scenery is bad.                 |
| Wild animals were plenty.                                              | Wild animals are few.                                       |
| No one felt hungry.                                                    | Most people feel hungry.                                    |
| Religion was their own.                                                | Different religion was brought by white people.             |
| There was tradition and culture.                                       | No tradition and culture. (they were cut off).              |

There may be some exaggeration or error in this comparison. However, if there are some mistakes it shows that Indian people greatly miss and love their deserted native village.

As for White Dog, a part of people were driven away from their native village because of the construction of a dam.

It seems that the Indian people have been treated like slaves or domestic animals by the white people.

#### IV. MERCURY POISONING PROBLEM AND ITS INFLUENCE

##### 1. Mercury Poisoning Problem and Racial Discrimination

The mercury poisoning problem this time should be understood in the context of the discriminative situation imposed by the governing class.

The focus of this problem was pollution of fish thinking particularly about the processes preceding this problem. People who eat fish are usually Indian people and if fish is polluted it becomes a big problem for Indians, but the white people remain safe. This relation may have been one of the reasons why any steps to prevent pollution were not taken before.

Secondly, a problem arises from the behaviour of the Government after pollution was discovered. The Government prohibited commercial fishing, eating fish taken locally and ordered the closure of tourist lodges in this area. This treatment brought about a crisis of community life for both reserves, because the lives of most people were mainly supported by commercial fishing and by employment as guides for tourist lodges.

##### 2. Unemployment and Broken Homes

There are two main social effects of mercury poisoning; one is unemployment and the other is starvation. There is, of course, another important influence that the people may have been damaged their health. However, I excluded this aspect in my paper because I am a sociologist and was not in a position to distinguish between the people who are poisoned with mercury and are not poisoned. As for this aspect, another paper will be presented from physicians.



Out of two social effects, I would like to consider unemployment first.

Commercial fishing and guiding at tourist lodges were the basis of the economy of both reserves before the mercury problem. Guiding began in approximately 1950's when the lodges were opened and has been one of the important sources of income for reserves. The lives of the Indian people in their native village were supported by commercial fishing and guiding during the summer time, picking wild rice in autumn and hunting or trapping during the winter. After relocation from their native land, it changed considerably, but still they could support themselves with income from commercial fishing and guiding during summer. However, this balance, maintained with difficulty, was lost with the arrival of the mercury poisoning problem. The Indian people lost their steady income both in winter and in summer.

Jobs as guides still exist in some tourist lodges, but over half of the people used to work at one of the closed lodges the biggest one in the area, Ball Lake Lodge. Guides who are still working at some lodges may get income from their job, but there is another big danger around them. Guides at tourist lodges have to cook and eat fish taken from polluted lakes once a day with tourists. This means that the guides' health is threatened with the danger of mercury polluted. In addition, guides take fish away to their homes, and families eat the polluted fish, too. This will also cause a health problem.

As a result of unemployment, the number of people living on welfare, increased greatly. Some people told me that the ratio of people who receive welfare increased 80 times compared with the time before the mercury problem. Other people told me that the total amount of welfare which the community receives was less than 500 dollars per year before the mercury problem but not is over 100,000 dollars per year. These figures show conclusively the increase in the number of people who have to live on welfare.

Welfare has another important influence on the community. This is idleness, frustration and alcohol abuse. They receive cheques at the end of every month and go to Kenora to change them for cash. There are various attractive things and places in Kenora and Indians are

apt to be tempted by alcohol. If they begin to drink they can't stop drinking until they get drunk. They drink because they want to forget all their suffering and their families can't receive any of the money which should be given as welfare.

On the other hand, people who receive money as welfare without working became more and more nervous because by nature Indians like working. This situation also leads to alcohol abuse.

### 3. Starvation and Broken Homes

Another big influence of mercury poisoning was the deprivation of the Indians' main food, fish. Indians were thrust down to starvation as all of wild animals' meat, fish and vegetables got by themselves were taken out as I mentioned already.

Now, the content of Indians' meal is very poor as far as the information I got from some of them show:

Case G-1; Job of head is a guide. He has to feed ten members.

breakfast- bacon and eggs, oat-meal

lunch - bread and jam, bread and butter, tea

supper - rice, hamburger

an annotation: No one except the head who is working as a guide has eaten fish after mercury poisoning problem. This family ate meat a couple of months ago and the meat was taken from moose. Actual problem relating to increase in weight of children has occurred for want of food.

Case G-2; No job because of old age. Receiving old age pension. This old aged couple only eat for breakfast;

oat-meal or banic (Bread Indians make by themselves.

This contains meat of fish which may be polluted with mercury), tea

lunch - ham or eggs or potatoes

supper - cornflakes etc. (snack)

an annotation: Neither of them have eaten fish since mercury poisoning problem has occurred.



Case G-8; The head is an office worker at band office. Young couple and a baby. The head graduated from high school.

breakfast - eggs and sausage, or sometimes bacon; and toast, tea.

lunch - meat or hamburger, macaroni or rice, soup. sometimes vegetables.

supper - meat or fish

an annotation: This family still eats fish. The head of this family was complaining about the cost of living and commodity prices sold by the store.

I could not get information at White Dog as the same way shown above, but there also we could see effects by mercury poisoning problem as follows:

Case W-3; All the member of family stopped eating fish since they had known real situation of Minamata disease in Japan, in this summer. There are eating bread and meat now and they, of course, have to buy them from the stores in their reserves.

Case W-4; All the family like fish, but stopped eating it because of warning given them.

Case W-6; As they can't eat fish, they have to buy food from the stores, but things in the stores are so expensive. Therefore, they can't buy enough food for them to eat and they are always hungry.

I think these cases tell us that Indians are pathetically trying to stop eating their main and favorite food, fish, though they know there is little food to eat in the reserves except ones bought from the stores.

The families who told me that they were eating some meat of domestic animal, bacon, ham and eggs etc. had a problem they couldn't buy enough quantity of food, and they still felt hungry. The other families were scarcely be able to buy such kinds of food containing protein because of extreme poverty.

CONCLUSION

The frustration caused from being unemployed, starvation and racial discrimination which have befallen the Indians heretofore are now making them grow wild and violent. It is told that the number of cases of suicide, injuring others, killing families and orphans are on the increase.

I drew a figure of the influence which Indian people suffered from mercury poisoning as Chart 1.

When health is damaged the ratio of destruction on the family will be wider and greater. In that case, the structure of the victim will be as Chart 2. I made Chart 2 based on concrete cases I got through interview with patients and their families in Japan who were damaged by pollution and drug. However, I have to add the fact that this figure can be applied to all of other patients and especially to the patients who are taken ill, hated or feared by people.



Chart 1

## Social Effects of Mercury Poisoning

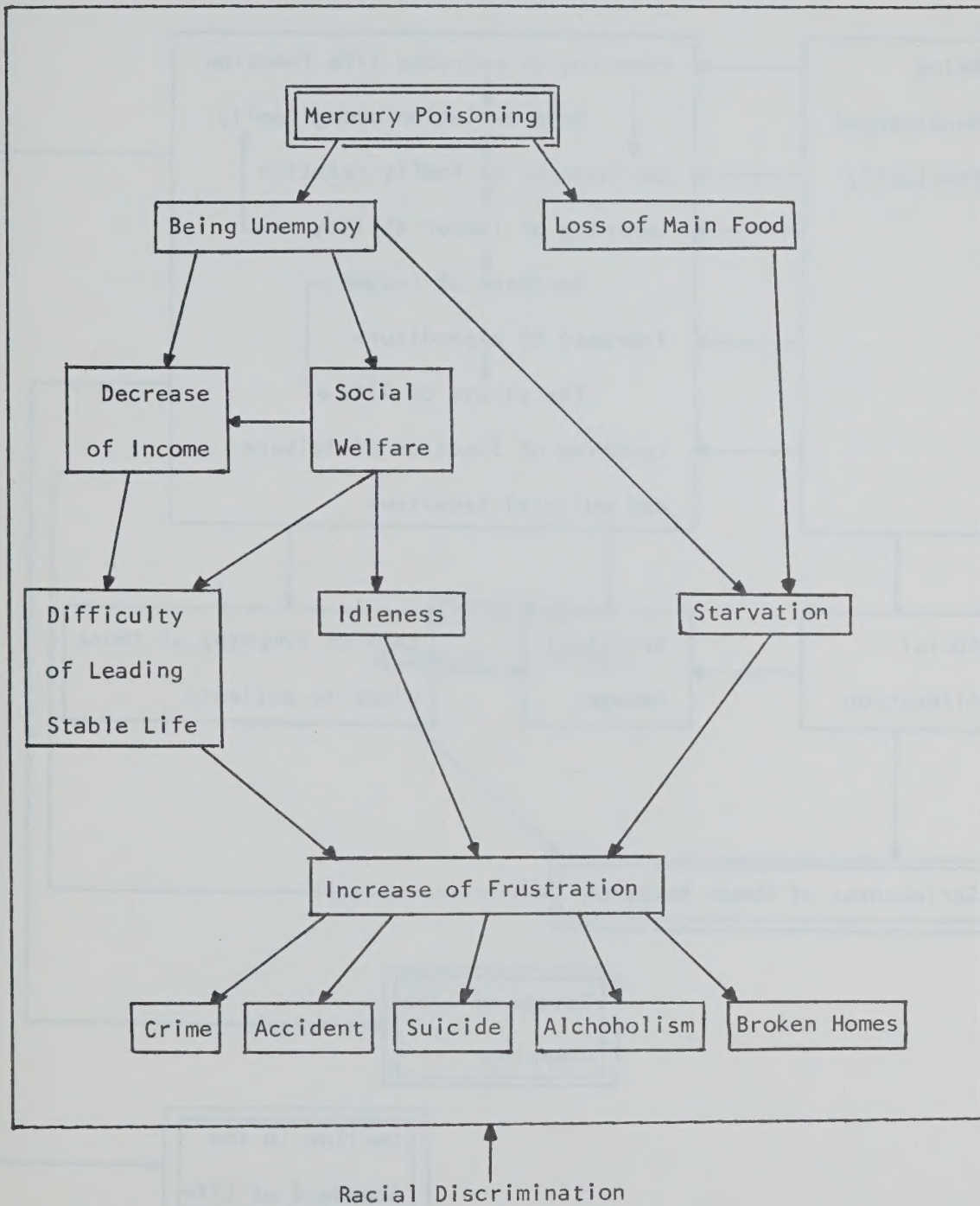
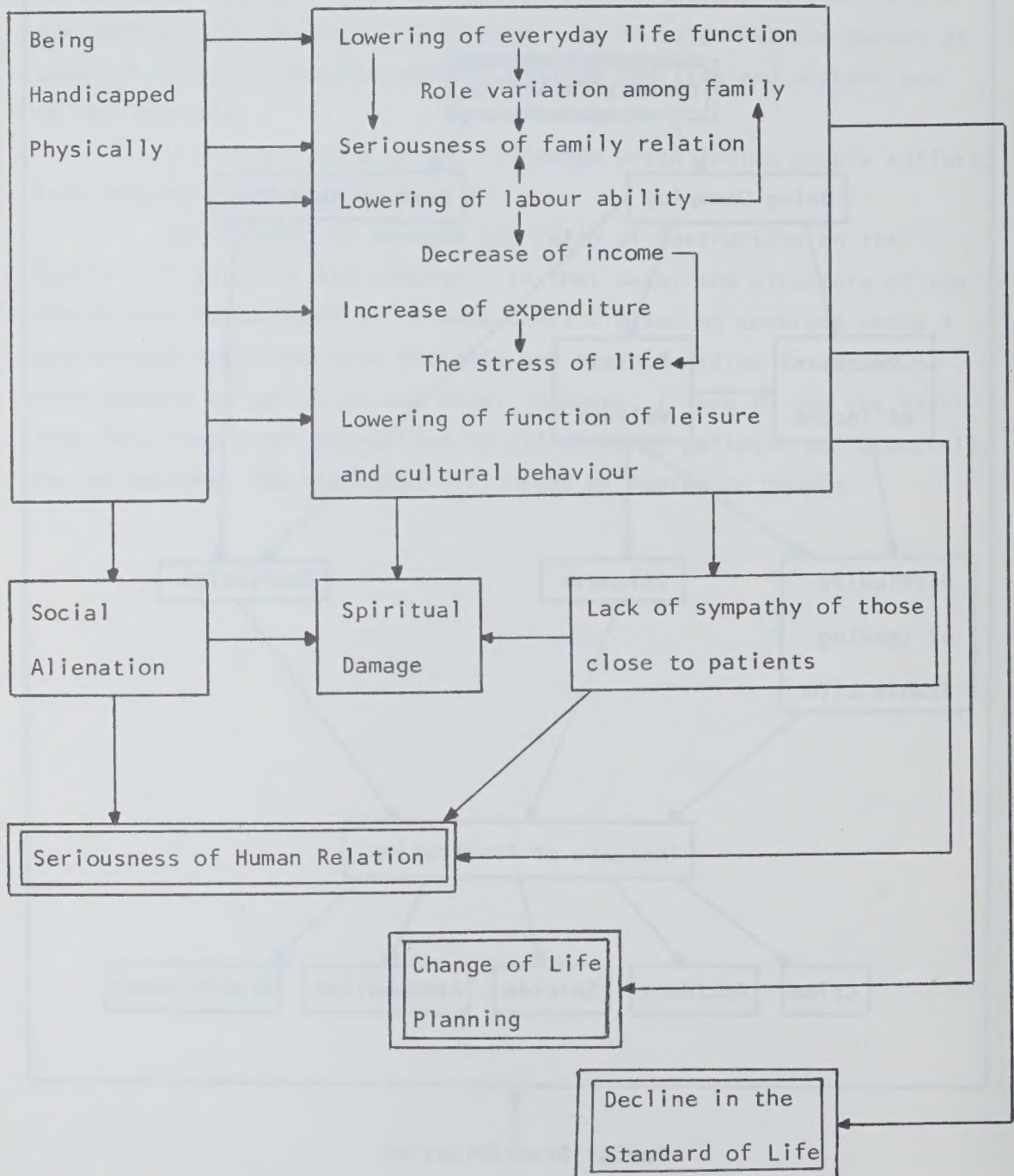


Chart 2

## Relation of Health Damage and Life Deterioration





1. The 1929 Times - London - December 22, 1929 - (London - 1929)

## Indians Not Poisoned: Canadian

OTTAWA, Dec. 22.—(The Times.)—The Canadian government has announced that it has no intention of poisoning the Indians of the Northwest Territory, as has been alleged by the United States.

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### APPENDIX III

#### NEWSPAPER CLIPPINGS

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## Indians Not Poisoned: Canadian

KYOTO — A Canadian Government expert, participating in an international environmental scientists' conference here, Friday rejected claims that Indians in his country are suffering from chronic "Minamata disease."

The "rebuff" came from L. Buffa, a scientist of the Canadian Government's Environmental Protection Agency, at a working group session on mercury poisoning on the fourth day of the 10-day International Congress of Scientists on the Human Environment.

Buffa said that the claims made Thursday by Japanese pollution experts were based on outdated data and that there is no longer any organic mercury poisoning case in his country.

Four papers were reported to the working group by Japanese pollution experts on the Minamata disease in Canada.

In one of them, Jun Ui, a lecturer at the University of Tokyo, reported that a total of three kilograms of mercury is being discharged daily into the Wabigoon River basin in Ontario where there are Indian reservations.

Ui also claimed in the paper that a total of 10 tons of organic mercury was discharged into the river basin in the past eight years and that fish there were contaminated with 10 PPM (parts per million) of mercury.

In response to such claims, Buffa said that fishing in the rivers had been prohibited and that the Indians were told by the Government not to eat fish from it.

He also stressed that a pulp company, the source of the mercury pollution, had switched to a diaphragm cell production process so that no mercury was used in its production of caustic soda in response to the Government's instruction.

Buffa said that as a result of such measures, mercury contamination of fish in the the rivers is now gradually decreasing.

### Ontario Gov't Move

TORONTO, Ontario, Canada (AP) — Ontario Attorney General Roy McMurtry says the provincial Government is considering legal action against Dryden Pulp and Paper Co. to

protect the rights of Indian children found to be suffering from mercury poisoning.

McMurtry said in an interview Wednesday that the Government's top environmental law expert has begun a study of legal moves the Government might take on behalf of the children of the White Dog and Grassy Narrows reserves of northwestern Ontario.

The Government has banned commercial fishing in the English and Wabigoon river systems downstream from the Dryden plant.

2 The Japan Times Friday, November 21, 1975 第 1000 号 (A)

## Canada Indians Suffer Chronic Minamata Disease: Japan Expert

KYOTO — A number of Canadian Indians in Ontario Province were found to have been suffering from a chronic case of Minamata disease, a Japanese expert on mercury poisoning said here Thursday.

Reporting at the current international environmental scientists' conference, Masazumi Harada, an assistant professor at Kumamoto University and an authority on Minamata disease, said the Canadian patients were seriously suffering from organic mercury poisoning.

Harada and other researchers, including Jun Ui, a lecturer at the University of Tokyo, and Teruo Kawamoto, a leader of a group of Minamata disease victims, visited the Indian reservations at

White Dog and Grassy Narrows in Ontario in March and August this year.

About 90 Canadian Indians, including fishermen, affected by mercury poisoning were examined and hair samples collected from them.

Sixteen out of 90 Indians were found to have narrowing of eye sight, impediment of speech, trouble in peripheral nerves and other symptoms peculiar to organic mercury poisoning, he reported.

The condition of nine of these patients were so serious that they would have been immediately designated by the Japanese Government as victims of Minamata disease if they had lived in Minamata, Kumamoto Prefecture, Harada said.

Scientists detected up to 80.3 ppm of mercury from sampled hair — over 20 ppm from hair samples of more than a dozen Indians.

Harada said that mercury level for these samples was about the same as the level for the samples from victims of Minamata disease in the vicinity of Agano River in Niigata Prefecture.

Minamata disease in Japan is an acute organic mercury poisoning, but the disease among Canadian Indians is suspected to be a chronic case of organic mercury poisoning, he concluded.

Harada explained that since the reservations were so large he did not visit individual bedridden mercury poisoning patients and had only examined those who were relatively light cases.

Serious cases were reportedly living in the Wabigoon River basin which flows through the reservations.



# Canada's Nature Said In Danger

Mainichi Daily News  
Friday, November 21, 1975

By Tetsuaki Shimizu, Staff Writer

KYOTO — Prof. Milton R. Freeman of the department of anthropology of McMaster University, Canada, said Thursday that sparsely populated Canada now faces environmental problems.

Prof. Freeman spoke on "Environment and Development: the Case of the Canadian Arctic" at the fourth-day session of the International Congress of Scientists on the Human Environment being held at Kyoto International Conference Hall.

He said that dangerously polluted air has been detected in Montreal and Toronto and in smaller industrial cities.

Pollution is even found in the arctic and sub-arctic regions, he added.

He pointed out that a major threat to the environment is the heavy equipment operating in the north to seek and exploit natural resources.

Species of animals unique to the arctic are nearly extinct, he said.

Asked how his government is dealing with the problem, he said: "In combination with industries, the Department of Indian Affairs and Northern Development is working hard to protect the environment."

At the outset of the afternoon session, Teruo Kuwamoto, a sufferer of the Minamata Disease, described the industry-caused disease and appealed to the participants to work together to prevent such tragedies.

Following reports on mercury poisoning in Japan by seven Japanese representatives, a discussion was held on mercury pollution.

"I'm very sad to say that mercury pollution is not a monopoly of Japan but has been reported also in Canada," said Victor A. Kovda, professor of Moscow University.

Pollution problems exist in Russia but they are not as serious as in the two other countries, he noted.

He said that mercury pollution could be prevented by setting up forms of international cooperation, by disseminating information and by improving technology.

"Japanese scientists are excellent and we can expect that the problems can be solved if we cooperate with each other," he said.

There is a proposal for conducting land reclamation work in mercury-polluted waters but that would lead to further contamination, Tokyo University researcher Jun Ui commented.



## *Environmentalists In Focus (1):*

# Canadian Lady Tackles World Food Problems

A charming Canadian scientist is drawing attention at the predominantly male congress on the environment now under way in Kyoto.

"You probably take me up because this is International Women's Year," Mrs. Margaret Biswas said to the reporter with a grin.

In her presentation on food and energy at a plenary session, Mrs. Biswas declared that the North American energy-consuming type of agriculture is not recommendable for developing countries, and that energy must be used more effectively in agricultural production.

She gave the presentation on behalf of her husband Dr. Asit K. Biswas who could not come to Kyoto as he is participating in another conference in Nairobi, Kenya. However, she is not a mere "pinch hitter." She is a co-researcher with her husband. Her well-prepared, interest-provoking presentation invited lively pro-and-con reactions and questions.

With a good sense of humor,

**Editor's Note:** Participating in the current International Congress of Scientists on the Human Environment in Kyoto are more than 550 experts representing over 30 countries. The Mainichi Daily News has interviewed several delegates whose countries are in different stages of industrial development.



Mrs. Biswas

the Canadian researcher replied to an African scientist's comment which could have easily provoked a heated debate between Northern and Southern countries. The comment was that food is wastefully consumed in the Northern countries, where too much body fat is a serious problem.

After responding to his comment, she added that she herself tries to eat steak, which she loves, less often as she preaches on food problems. Her additional remark drew laughter in the packed room, relaxing tension.

Mrs. Biswas came to Japan with knowledge about the pollution here as "a lot of governmental documents and reports on Japanese environmental disruption are available in Canada."

But she hasn't seen the reality of the pollution in Japan yet because she flew to Osaka and came directly to Kyoto where pollution is not much in evidence.

"Do we have pollution

problems in Canada? Yes, we have air pollution, very bad in Montreal. We have water problems, too. Water pollution is worsening, which has enforced legislation," she said, "but they are not as bad as in Japan.

"There is another serious problem which is not dealt with very much anywhere; that is that chronic exposure to small amounts of pollutants over many years could be as serious as intense exposure. We call it the 'threshold effect.'"

She worked as a research scientist on energy for the United Nations in Nairobi from 1974 until May this year after working four years at the Department of Environment of Canada, which was established in 1970.

She was brought up in Winnipeg in Canada's wheat-growing belt, and earned a BS degree in physics at the University of Manitoba and a master's degree at McGill University in Montreal.

She met Dr. Asit K. Biswas, a former professor of the University of Strathclyde, Glasgow, seven years ago when she was working at the Department of Energy, Mines and Resources of Canada.

The two were assigned to the newly established Department of Environment, an association which led to their marriage in 1971. Their current main concern is food problems.

"I'm not an advocate of women's liberation. I'm enjoying being a wife. But I don't have children. We like working and traveling. If we had children, this would be impossible, because North American children are not good travelers," she said, smiling.

(By T. Hikino)

Mainichi Daily News  
Friday, November 21, 1975



#### APPENDIX IV

SUMMARY OF DISCUSSION ON CANADIAN  
SITUATION AT CONGRESS OF SCIENTISTS  
ON THE HUMAN ENVIRONMENT, Kyoto,  
November 17-26, 1975





APPENDIX IV

Working Group C. C-4 (B)

Freeman: The north district of Canada has been hitherto mainly the place of hunting and fishery by natives, but now the environment of this district is disrupted by the economical development policy of the Canadian government. Especially by the activities of nickel mining, etc. the environment is polluted and, through food chain of fish, white bear, mink and natives, the accumulation of the pollutant is becoming dangerous.

Harada: In the hair of the Indians settled in White Dog, Grassy Narrows, the same level of mercury deposit as in Minamata has been found. The level becomes high in summer when the natives take more fish and low in winter. Neurodisturbance and narrowed visual field were found among several Indians. The typical symptoms of mercury poisoning, Hunter-Russel syndrom, shows acute symptoms. The diseases of chronic poisoning by low level pollution differ from the abovementioned acute symptoms. It is wrong to think the symptoms different from Minamata disease cam from other causes. Based on personal investigations and epidemiological research it is reasonable to decide some of the Indians are suffering from organic mercury.

Nakanishi: We found the highest pollution just downstream of the chemical factory at Dryden. Investigations on sauries and craw fish lead us to believe that the factory is the pollutor of mercury. This district is a low humid area. The time of water staying is very long. It is necessary to take three years water to move from the spot to the seashore. The movement of bottom deposit is almost negligible. The situation is very serious.

Iijima: Mercury is disrupting not only the health of Indians but also their lives. Because they lost their main income sources of fishery and guides, they lost their will to work. Compensation only increased the number of alcoholism.

Ui: In colder districts, the coefficient of accumulation is higher than in warmer districts. It is unreasonable in the cases of less excretion of mercury comparing Minamata to evaluate less dangerous.

Buffa (Canadian Federal Environmental Protection Service):

The reports of Japanese scientists may give the impression that the Canadian government took no deliberation concerning this event. This is not the case. The Dryden Factory stopped discharges of mercury mud in 1970, and is planning to change their process to the diaphragm method to prevent any further discharge of mercury.

Kawamoto: The disaster of Minamata has not come to end. The disaster today originated in the fact that Chisso Company monopolized all the manpower and resources of Minamata district.

Nishimura: Victims are building their homes by compensation. But there are no considerations for the disease. It is necessary to make plans to lessen their pain as much as possible.

Fukai: In the Minamata district, until now, fishing is performed against prohibition and the fish is sold at blackmarket. This causes expansion of the danger of mercury poisoning to the inhabitants of unpolluted areas. The government must take a drastic new policy for fisheries.

Shibata: In Japan, there are ample sources of labour power in the rural districts. This is the reason the factory ignored the health of the inhabitants. The government also paid scarce attention to their health, only pursuing economic growth, encouraging mass production and mass consumption. The economic growth of Japan was achieved by the prodigal use and disruption of resources, environment and labour power. There is a limit for the octopus to survive eating his own legs.

Fujino: We found victims of mercury poisoning in Tokuyama district also. But the government is denying to designate them as mercury poisoned, for the reasons that the mercury discharged in Tokuyama was inorganic and the symptoms of victims did not show the typical symptoms of Minamata. But the possibility of wrong decision of the government is very high. Because by the epidemiological study we found three victims of the same symptoms in one family and, in the body of fish of Tokuyama Bay, we found the accumulation of organic mercury.



Michajlow: In Poland, people's concern on water pollution is very high since 20 years. After the establishment of Environmental Agency in 1972, the collaboration of scientists of many fields has become very active. Recently, we began to cooperate with the neighbour countries on the preservation of forest.

Kovda: I was strongly impressed by actual status of Minamata, which was already known in Soviet also. And the example of Canada also gave a strong concern to me, a Russian who lives in the same north districts. I feel strong necessity of the collaboration of scientists of all fields.

#### Problems on Discussion

1) About the deposit of pollutants.

There remains danger, if we adopt conventional technique in a hurry. But, at the same time, we can not abandon it. The study in these fields is most urgent.

2) Special problems in colder regions.

The ecosystem in colder districts is very fragile, and it is very difficult to recover when it is once disrupted. Pollutant deposit through the animal chain is more speedy and higher than in warmer districts.

3) For the scientists.

They must consider the facts and find a direction for research and investigation.









